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Houston, Daphne Moses, Ph.D.

Kansas State University, 1993

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AN EXPLORATION AND ANALYSIS OF THE RELATIONSHIP AMONG LEARNING STYLES, TEACHING STYLES, GENDER AND PERFORMANCE IN A COLLEGE COMPUTER SCIENCE COURSE

by

DAPHNE MOSES HOUSTON

B.A., Howard University, 1987

A DISSERTATION

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CHAPTER ONE
INTRODUCTION

Individuality is the sum of characteristics or qualities that set one person or thing apart from another. This definition does not carry any implications as to the importance of individuality or how it should be interpreted, particularly in regard to the learning process.

Since individuality is generally accepted, the question of its importance and the ways in which it should be managed remain as an area of exploration. It is not unlikely that the complex act of learning is influenced by the existence of so many individual variations.

The ways in which people differ from one another may be grouped under four headings: 1) anatomical, 2) physiological, 3) biochemical, and 4) psychological (Anson, 1951).

In the area of psychology, the existence of individuality has been recognized for quite some time, and many books have been written on the psychology of individual differences. These individual differences are sure to affect the ways in which we process information, thus affecting the ways in which we learn.

Dimension of the Problem

The learning process could be greatly improved by additional knowledge about individuality. Distinct individual differences in strategies and aptitudes in learning have been revealed (Clements,1985). This implies that instruction must be adaptive in order to provide equal opportunities. To do this, educators need to be aware of individual differences such as learning styles. This study deals with learning in general, but specifically with the task of learning to program, in an introductory computer programming course.

Understanding how people learn to program and how to make that learning process more effective is important, particularly as the need for expert programmers continues to exceed the number available. Even more importantly, as the number of students entering technical fields continues to decline, educators must explore ways of combating the decline. This is especially important with respect to culturally diverse students and to females.

Sherry Turkle (1984), expressed the need to explore this matter further by stating, " most importantly, being cognizant of the fact that people do learn differently is a first step to enhancing and individualizing instruction."

Individual needs are paramount in the effort to effectively educate students. The range of these needs implies that there is not a single method of instruction for high academic achievement; the experiences are highly influenced by one's cognitive abilities. Certainly, individuality of learners may account for their differences in performance of acquiring skills.

In developing a full understanding of programming it is of primary relevance that cognitive processes underlying programming tasks be considered. Programming is a complex skill that challenges us to further examine the ways and influences of the ways we think and learn. By examining the differences that exist among students, one can build a framework for alternative approaches and strategies.

One way that educators have found to address the problem of mulitmethods of learning has been the movement toward "individualized instruction." This has been a buzzword for educators who are concerned with tailoring instructional approaches to student needs, interests and skill levels. One systematic, or more scientific way to determine what works best for individual learners, has been the exploration of learning style theory which serves to provide a better match between how a person best gains knowledge and the methods used to impart that knowledge. Research in the area is not widely known, but Smith (1982) indicates the great diversity in research on what, how and whom to assess in learning styles.

Learning is not a simple task; socioemotional factors are believed to play into the learning process, as well as personality and culture. By investigating these factors from a cognitive psychologist/educator's point of view, perhaps one can see how learning styles, and for that matter, teaching styles relate to student performance. In a task like computer programming which involves, in part, step by step procedural instructions, it is particularly imperative to find out how learning styles and teaching styles relate to performance. Cognitive science's interdisciplinary nature has also provided insight into the significance of cognitive skills, how they are acquired and when they are needed. However, there is still room to explore and analyze the learning process from a skill acquisition perspective. Many studies dealing with cognition and problem solving are general and typically deal with children. There is a vacuum of knowledge of the influence of cognitive skills involving science and technology. And an even more barren realm exists in fields like computer science for adult learners. The specific study of adult learners is important as the typical college student body becomes more "nontraditional."

While many studies provide information of a predictive nature when dealing with learning styles it is the researcher's goal to use learning styles to aid in the inclusion of as many different types as possible. Success should not be restricted to certain types of learners. The study described in this document was primarily designed to determine the relationship between learning styles, teaching styles, gender and performance in an introductory programming course. This chapter contains the researcher's objectives, research questions and the factors which set the boundaries and limitations of the study.

Background and Significance

Considerable research has been conducted to identify factors that are associated with programming outcomes. In the 1950's cognitive psychologists began to explore computer programming as human performance. Weinberg's book, *The Psychology of Programming* (1971) took us past the long held perception of the computer wizard aimlessly "hacking away at some black box." Following Weinberg, more empirical studies of programmers were conducted.

The study of individual differences led to looking at "What it takes to be a good programmer." Further examination of the cognitive prerequisites for programming were explored. Weinberg (1971) understood the significance of personality and other facets of cognitive style when he summarized the importance of personality in relation to programming tasks:

> Because of the complex nature of the programming task, the programmer's personality -- his individuality and identity -- are far more important factors in his success than is usually recognized... there seems to be evidence that critical personality factors can be isolated and associated with particular programming tasks -- at least in the sense of their possession rendering one incapable of performing that task well. Consequently, attention to the subject of personality should make substantial contributions to increased programmer performance -- whether that attention is paid by a psychological researcher, a manager, or the programmer himself (Weinberg, p.158).

Interest in the more psychological aspects of human performance variation has led to research into cognitive style. To provide a wider range of people with the necessary skills, instructors must teach in a way that students can actually learn them well enough to become expert programmers. However, because learning style was not a subject given much consideration in the past, certain people who did not fit the mold were excluded from these careers.

Pea and Kurland (1983) reported,

> The common fear for the individual who would like to learn programming, and the concern of educators and employers (frequently motivated by cost effectiveness), is that there are some persons who are either not capable of

being trained to program, or who are not developmentally ready in that they need to learn to know more fundamentally relevant things before embarking on the task of learning to program (Pea & Kurland, p.2).

Because programming is a highly cognitive task, the cognitive process involved is complex. The researchers often have opposing views of the theory of learning styles and how they should be measured. As a result of a growing base of learning style theory, and the noted significance that socioemotional factors have on the learning process, there is much interest in alternative instructional approaches.

Although much of the learning styles literature is targeted toward math and science educators, Schoenfeld's (1989) study on cognitive science in math and science instruction, concluded that discussions themselves (cognitive science and mathematics education) were highly interactive with contributions from all the constituent disciplines. He went further to state that cognitive analyses are often complicated and incomprehensible. He stated, "The details of cognitive research may not be of interest to anyone except cognitive researchers, although the implications and underlying ideas may be."

Just as the goal of these disciplines is to make instruction in programming better, the goal of taking the implications that cognitive studies provide and successfully utilizing that knowledge is quite challenging, but in the long run, may actually make teaching more effective.

Purpose of This Study

The purpose of this study was to develop a better understanding of the teaching and learning process and to gain insights which will enable us to improve instruction in computer programming. This project investigated the effects of student learning styles, teaching styles, and gender in relation to course grades in computer science.

Our understanding of the forces which motivate programmers and of the cognitive processes involved in learning programming is shallow, as is our knowledge of the learning and teaching methods that best facilitate acquiring the necessary skills for programming. Programming is complex and novice programmers bring a variety of cognitive skills and styles to the challenge of programming. Individual differences that exist prior to learning new skills are important instructional conditions for planning instructional treatments (Foreman, 1987).

A survey of research on learning styles (Dunn, Beaudry & Klaus, 1989) found that research was confined to sample populations from kindergarten through high school. Thus, there remains a paucity of learning style research at the college level.

By studying the performance of both matched and unmatched students with their instructors' learning/teaching styles, we can further explore the role of implementing alternative styles of instruction in hopes that achievement will increase. Armed with a new understanding of learning styles, instructor styles and their effects on performance, we may be able to suggest ways to improve instruction so that females and culturally diverse students will consider entering these fields in greater numbers. Improved instructional methods aimed at a variety of learning styles may provide an interesting and attractive option for reaching more students.

Specifically, the research questions to be answered were:

1. What is the effect of matched vs. unmatched teaching and learning styles on student grades in (a) lab and (b) the lecture where learning style is measured by the Gregorc Style Delineator ?

2. Are there differences in performance among different learning styles as measured by the Gregorc Style Delineator and performance in computer

programming as measured by (a) lab grades and (b) the lecture grades for required assignments?

3. Does gender affect student grades as measured by (a) lab grades and (b) lecture grades for required assignments? and does gender interact with learning style on these performance measures?

Significance of the Study

This study is important for three reasons. First, the study provides information concerning the significance of learning and teaching styles in helping understand more about the process of learning programming.

Second, the results provide further descriptive information concerning the cognitive processes involved in computer programming. Third, descriptive information about interaction effects of learning styles and gender as they relate to computer science will be documented. Such information is important to curriculum planners, instructors and students as society's interaction with technology in general, and computers in particular, continues to increase.

Assumptions of the Study

1. It was assumed that each participant voluntarily completed the learning style inventory in a conscientious manner.

2. It was assumed that each student participant and instructor does have a learning style preference.

3. Normal distribution of data was assumed.

Limitations of the Study

The study was conducted under the following limitations:

1. The learning style instrument was used merely as an indicator. The results cannot be generalized to older or younger students or other regional universities.

2. The sample of students in this study was relatively small and may not be generalizable to all college computer science students.

3. The sample of students in this study was in an introductory programming course based on the procedural programming language, Pascal. Therefore, the results may not be generalizable to courses based on other types of programming courses.

Definition of Terms

To aid in clarity a list of terms are defined here to identify their specific usage and meaning as they applied to this study.

Computer Program. A series of instructions to process data. It may be in a high-level source form, which requires intermediate processing before the computer can execute it, or it may be in an object form directly executable by the computer. A Pascal example is provided below.

```
PROGRAM PAYROLL (INPUT, OUTPUT);
const
TAX = 25.00;
var
RATE, GROSS, NET : REAL;
begin
  READLN (HOURS);
  WRITELN ('Hours worked are ', HOURS);
  READLN (RATE);
  WRITELN ('Hourly rate is ', RATE);
  GROSS := HOURS * RATE;
  NET := GROSS - TAX;
  WRITELN (' Gross pay is $', GROSS);
  WRITELN (' Net pay is $', NET
end.
```

Computer Programming. A complex configuration of activities which vary according to the language and the environment. The activities include problem definition, design and organization, code writing and debugging, as stated by

Kurland, Clement, Mawby & Pea (1987). This study refers to procedural programming in general, and specifically in the language Pascal.

Cognitive Style. . In the literature reviewed, the term cognitive styles has been used synonymously with learning styles, modalities and teaching/instructional styles.

Learning Style. Learning style is the individual way in which a person gains knowledge and understanding. Gregorc (1979) defines a learning style as consisting of distinctive behaviors which serve as indicators of how a person learns from and adapts to the environment. The specific learning style in which a learner is categorized will be based on his/her score on the Gregorc Learning Style Delineator, as interpreted by the Delineator's instructions.

Teaching Style. Teaching style consists of a teacher's personal behavior and the media used to transmit or receive data from the learner (Gregorc, 1982, p.22). In this study, learning/teaching style of the instructors is determined by the Gregorc Learning Style Delineator (GSD) score and was thus a narrower definition (no media, for example).

Definitions of other terms are presented in the review of the literature.

Summary

The primary purpose of this study was to determine the relationship between matching and unmatching of learning styles and teaching styles on performance in a university introductory computer programming course. A secondary purpose was to determine the relationship of learning styles on performance and third, to determine the relationship between gender and performance in a university introductory computer programming course.

This chapter contains the researcher's objectives and questions, in addition to those factors which set the boundaries and limitations of the study.

The following chapter contains a detailed review of the relevant literature and research related to this study.

CHAPTER TWO

REVIEW OF THE LITERATURE

The three major objectives of this study are: 1) to explore the relationship between matched and unmatched conditions of learning and teaching styles and their effect on performance in computer programming 2) to examine the relationship between learning styles and performance in computer programming and 3) to examine possible interactions between learning styles and gender as they may affect performance in computer programming. This chapter contains a literature review.

Historical Background on Learning Styles

The nature of personality and "types" has been a topic of exploration throughout intellectual history. The early Greek philosophers sought to identify various "personalities" (Littauer, 1983).

In the early part of the twentieth century, psychologists, especially German psychologists, were instrumental in developing "psychological types" (Guild & Garger, 1985). In the later part of the twentieth century, the use of the words "types" and typology served, for the most part, to classify differences and preferences.

According to Guild and Garger (1985), the word "style" was first used by Gordon W. Allport (1937), an American, who defined psychological patterns. Reinert (1976) used the words "learning style" in making the assertion that "an individual's learning style might be directly related... to which hemisphere of the brain is most highly developed for that individual." Guild and Garger (1985) also attribute James Keefe (1982) as using the words "learning styles" in introducing a collection of papers on style and brain behavior research. Gade (1989) quotes Keefe :

Knowledge about learning styles and brain behavior is a fundamental new goal in the service of teachers and schools. It is clearly not the latest educational fad. It provides a deeper and more profound view of the learner than previously perceived, and is part of the basic framework upon which a sounder theory and practice of learning instruction may be built (Gade, p.68).

Defining Learning Styles

Looking for a "scientific" way to determine how learners learn best, educators have turned to learning style theory to provide a better match between how a person best gains knowledge and the methods used to impart that knowledge. In this search, a number of definitions of learning style have evolved.

Learning style/cognitive style refers to the manner in which individuals process, perceive and organize information - how they think (Witkin, Moore, Goodenough & Cox, 1977). Gregorc (1982) defines learning style phenomenologically by stating, "Learning style consists of distinctive behaviors which serve as indicators of how a person learns from and adapts to his environment. It also gives clues as to how a person's mind operates."

Keagan, Moss and Sigel (1963) define cognitive style as "stable individual preferences in mode of perceptual organization and conceptual categorization of the external environment." Goldstein and Blackman (1978) also lean in the conceptual and perceptional direction. They define cognitive style as "the structure rather than content of thought, the ways in which individuals conceptually organize their environment." Dunn, Dunn and Price (1979) focus on variables within the learning environment. Their definition states, "Learning style is the manner in which at least 18 different elements from our basic stimuli affect a person's ability to absorb and retain."

Witkin's (1973) broader view describes cognitive style as, " a potent variable in a student's academic choices and vocational preferences; in students' academic development through their school career; how students learn and teachers teach; and how students and teachers interact in the classroom." David Hunt (1979) focuses on the conditions a learner is under during the learning process. His definition of style refers to the degree of structure a person needs to process information about persons, places and events. Keagan (1971) views cognitive style this way, "... it is the process by which knowledge is acquired perception, memory, thinking and imagery ..." Messick (1976) defines cognitive style as each individual's preferred ways of organizing all that he sees and remembers and thinks about.

Several researchers have studied the ethnic and cultural implications that learning style theory lends itself to. Ramirez (1989) suggests learning style reflects the influences of parents, peers, the community, the culture of the subgroup and the culture of the dominant group.

Learning Styles Models and Instruments

In the last decade, a number of people have developed and applied models that use the concept of learning styles. There are over 30 learning style models and instruments which range from complex to simple in nature (Friedman & Alley, 1984). Claxton and Murrell (1987), borrowing from Curry (1983) used the metaphor of an onion as a way to describe the four different levels of learning style. Figure 1 is presented as a way of organizing the many learning style models which are presented. They stated:

> At the core of the onion is style in the sense of basic characteristics of personality. Information processing models, describing how people tend to take in and process information, form the second layer; social interaction models, dealing with how students tend to interact and behave in class, make up the third; and learning environment and instructional preferences constitute the fourth (Claxton & Murrell, p.27).

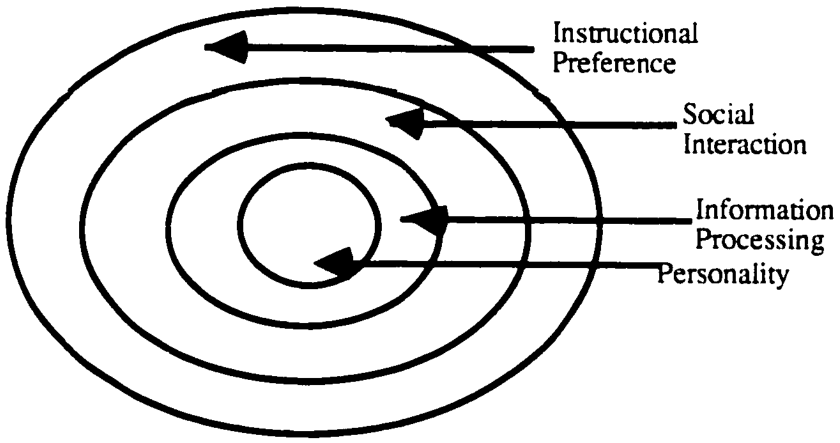


Figure 1. Four Levels of Learning Styles. Adapted from: Claxton & Murrell (1987, p.27).

Several of the more broadly mentioned models across the four levels are Gregorc, Witkin, Canfield, Myers and Briggs, Fischer and Fischer and Dunn, Dunn and Price. Under the personality level two major models are reviewed here:

Witkin.

Herman Witkin, a profound theorist and researcher of cognitive styles, worked with pilots in the early development of his Field Independent and Field Dependent Theory of Learning (Guild and Garger, 1985). The Embedded Figures Test (Witkin, 1969) came out of this work. The embedded figure test is composed of geometric figures in a more complex geometric figure. Those who readily found the embedded figure were known as field independent and those who search for a length of time were referred to as field dependent.

Myers-Briggs.

According to Myers-Briggs, learners are orderly and consistent in the way that they use perception and judgment. (Myers& Briggs, 1983). Perception includes the processes of becoming aware of things, people or ideas. Judgment includes the processes of coming to conclusions about what has been perceived.

The Myers-Briggs Type Indicator (Myers & Briggs, 1983) is a forced-choice, self-report personality inventory of 126 items. An individual's type can be measured along four bipolar dimensions:extroversion/introversion; sensing/intuition; thinking/feeling and judgment/perception.

Gregorc.

Gregorc's model (1985) lies in his understanding of how a person perceives information. Learning style consists of distinctive, observable behaviors that provide clues about individuals and how they relate to the world. According to Gregorc, these styles are manifested as behavior and register in our conscious minds as preferred means of learning and teaching. Gregorc believes that a person perceives information on a continuum between abstract and concrete. These qualities suggest that people learn in combination of dualities: (a) concrete-sequential; (b) concrete-random; (c) abstract-sequential; and/or (d) abstract-random. Preferences for a particular set constitute a learning style. Thus, the behaviors and related preferences, allow the identification of styles through observation, interviews and paper and pencil instrumentation.

An individual's perception may fall anywhere on the continuum, but there is normally a preference to one end or the other (Guild, 1985; Gregorc, 1985).

Abstract Sequential learners have excellent ability to use written, verbal and image symbols; have conceptual images which they match to what they read or hear; prefer rational and sequential presentations; learn well from authorities, and prefer a variety of learning experiences.

Concrete Sequential learners tend to do well in hands-on experiences; appreciate order and logical sequence; like to use touchable materials; follow directions well; prefer clearly ordered presentations, and tend to like quiet atmospheres.

Concrete Random learners have experimental attitudes and behaviors. They make intuitive leaps in the learning process. Unstructured problem solving through trial and error is preferred. These students tend to learn well individually or in small group settings and resent teacher intervention in their learning effort.

Abstract Random students are extensively influenced by the teacher's delivery and personality. They are influenced by a learning experience as a whole more than by separate tasks. They prefer to receive information in an unstructured manner; prefer activities involving multisensory environments; prefer freedom from rules and guidelines. They also prefer to gather and organize materials themselves (Gregorc, 1985, pp. 23-24).

Kolb.

According to Kolb, learning style is a result of hereditary equipment, past experience, and the demands of the present environment combining to produce individual orientations that give differential emphasis to the four basic learning modes postulated in experiential learning theory: Concrete Experience (CE); Reflective Observation (RO); Abstract Conceptualization (AC); and Active Experimentation (AE). The Concrete Experience (feeling) mode represents learning by doing, by experience, and by direct contact with the real objects, situation or environment. This learner's experience is controlled with little or no risk taking. The Reflective Observation (Watching) mode represents learning by observation, imitation, and reflection upon how things work. In the Active Experimentation (Trying), mode the notion of risk-taking is important. After developing the abstract hypothesis the student risks proving or disproving it through experimentation. An orientation toward abstract conceptualizing (thinking) means that a student conceives a hypothesis to be tested or would develop cognitive images or abstractions. This person grasps philosophical concepts, and is able to understand and think about theories. This learner finds the language of imagery as real as the language of concrete objects.

The Kolb Learning Style Inventory is a self-report instrument based on a rank ordering of four possible words in each of nine different sets. Each word represents one of the four learning modes.

Schmeck.

These researchers state that learning style is a predisposition on the part of some students to adopt the same learning strategy regardless of the specific demands of the learning task (Schmeck, 1977). They believe it is important to assess learning style from a behavioral-process orientation focusing upon actual classroom behaviors.

The Inventory of Learning Processes developed by Schmeck (1977) scores six experimental scales defined through factor analysis:

1. *Deep Processing*: Emphasizes use of higher order thinking skills during study: reasoning, analyzing, comparing, applying and seeking understanding.
2. *Shallow Processing*: Measures a tendency to memorize, simplify, avoid complications, fragment, and be intellectually dependent.
3. *Elaborative Processing*: Emphasizes processes employed to personalize information, such as restating, visualizing, relating, questioning, summarizing and applying.
4. *Serialist Processing*: Measures a tendency to pay attention to detail, sequential procedures, effort, overlearning, and proceeding rationally without intuitive leaps.
5. *Self-efficacy*: Self-perception as a competent learner able to plan work, draw inferences, remember information and pass examinations.
6. *Holistic Processing*: Measures a tendency to first build the big picture and then fit in the details. It includes imaginative elaboration, speculation, playfulness, and vivid imagery (Schmeck,1977,pp.423-25).

The following models and instruments fall under the Social Interaction Level:

Grasha.

Most of Grasha's investigation has been centered on high school and college students (Grasha, 1982). Six types of learners are classified in their model.

1. Competitive students learn best when competing with someone else on a particular task.

2. Collaborative learners prefer cooperative projects and class assignments which require sharing ideas and talents.

3. Avoidance learners are usually disinterested in the course content and do not participate with teacher or classmates in activities.

4. Participant learners thrive on active engagement in the learning process. They are very responsible and enjoy contact the classroom atmosphere.

5. Dependent learners show little intellectual curiosity and do only the minimum.

6. Independent Learners prefer to work alone. They do not interact with others when necessary (Grasha-Reichmann, 1982, pp. 40-41).

At the level of Instructional Preference are the following models:

Smith and Renzulli.

Smith and Renzulli (1984) have a contrasting approach to their learning style model. They see learning styles as the direct counterpart to teaching styles. They assess learning styles using their inventory of 65 items concerning student attitudes toward lecture, projects, drill and recitation, peer teaching, discussion, teaching games, independent study, simulation and programmed instruction.

Dunn and Price.

According to Dunn and Price (1984) there are five types of stimuli: environmental, emotional, sociological, physical and psychological. These factors impact a student's learning. There are three to six elements within each stimulus. The environmental elements are sound, light, temperature, and design. Emotional factors include motivation, persistence, responsibility, and need for structure or options. Sociological factors include colleagues, self, pairs, teams authority and varied learners. The physical elements affecting one's learning style are perceptual strengths (5 senses); intake (food); time of day or night energy levels; and need for mobility (fitness). And finally the psychological elements are analytic, global and field independent/field dependent and reflective/impulsive.

Teaching Styles

Education cannot be limited to the learner, Because each student has a learning style it is important that the teaching style be one that "speaks to" that learning style, thus the examination of the prior research on teaching styles is included in this study. Allen (1988) cites Entwistle (1981) who says, "The implication of education is that teachers need to provide opportunities for students to learn in ways which suit their preferred style of learning" (p.95).

The idea of teaching style is quite different from method of instruction used by a teacher. Teaching style theory is closely related to learning style theory. It refers to a classroom mode, a pervasive way of approaching the learners that might be consistent with several methods of teaching (Gade, 1982). According to Gregorc (1979), teaching style is more than methodology in that it extends to subtle messages which attract those who think along similar lines. Gregorc claims that teaching style refers to a teacher's personal behaviors and the media used to transmit or receive data from the learner. Smith (1982) concurs with this opinion and states, "Teaching style refers to an instructor's characteristic behavior in the teaching-learning situation" (p. 79).

Garcia (1982) describes teaching style as the manner in which a teacher facilitates learning. A teacher's style reflects his or her personality and judgment about how to best facilitate classroom learning.

Dunn and Dunn.

The Dunn and Dunn Model (1974) of teaching style isolates nine elements. The nine elements defined by the Dunns are:

1. Education Philosophy. Education philosophy involves personal, community, and national values of education.

2. Student Preferences. Student preferences refer to the student personality types and behaviors that are important factors in how a teacher handles a class.

3. Instructional Planning. Instructional planning refers to the process of diagnosing, prescribing and evaluating student needs.

4. Student Grouping. According to the Dunns student grouping refers to the way a teacher permits sociological learning to take place.

5. Room Design. The teacher's use of the physical room with particular attention to the instructional areas to meet the needs of students are the emphasis.

6. Teaching Environment. The teaching environment refers to the teacher's scheduling of class activities and student mobility.

7. Teaching Characteristics. The teacher's flexibility and amount of direction and supervision is included in this area.

8. Teaching Methods. The delivery methods and levels of student participation are concerns in this area.

9. Evaluation Techniques. These are the primary concerns of the Dunns. Formal or informal assessment of student experience is desired.

Garcia.

Garcia (1982) categorizes teaching styles on a decision making continuum as autocratic, democratic or laissez-faire :

An *autocratic* style will not share the decision-making process. What is taught and the manner in which it is taught is determined solely by the teacher. The *democratic* style teacher shares a portion of the decision making with the learners. The style is a combination of directive and non directive teaching. The third type, the *laissez-faire* style is non- directive. Most, if not all, of the decision making is delegated to the students so that at any given time they may select what to study and how to study it. Teachers are urged to use the three styles interchangeably and to maintain flexibility in style (Garcia, 1982).

Fischer and Fischer Model

According to Fischer and Fischer (1979), the manner in which teachers conduct a class reflects their own learning styles which in turn, then influences student achievement. They assert:

> The idea of teaching style is quite different from method of instruction used by a teacher. It refers to a classroom mode, a pervasive way of approaching the learners that might be consistent with several methods of teaching. (Fischer and Fischer, 1979, p. 251)

Some of the observable teaching styles used in classroom instruction are:

> *Task Oriented* teachers prescribe the material to be learned and demand specific performance on the part of students using an explicit system of accounting.
>
> *Cooperative planners* plan the means and ends of instruction with student cooperation. They guide the student's learning; however, opinions of the learners are respected and student participation is encouraged.
>
> *Child centered teachers* provide a structure for students to pursue whatever interests them. The curriculum fits the style as the interest and curiosity of the child supersedes teacher preplanning.
>
> *Subject centered teachers* focus on organized content to the near exclusion of the learner.
>
> *Learning centered teachers* have equal concern for students and curricular objectives and the material learned, helping students of all abilities develop autonomy in learning.
>
> *Emotionally exciting teachers* enter the teaching/learning process with zeal and usually produce a classroom atmosphere of high emotion and excitement while the counterpart is more subdued (pp.47-48).

Allen (1988) cites the following teaching styles model:

Witkin's Teaching Styles Model.

In addition to measuring learning style, Witkin's theory of perception is also used tc measure teaching styles as field dependent or field independent. Witkin established the premise that one's teaching style is determined by one's learning style preferences. The *Field Dependent Teacher* stresses and plans for active participants in goal setting; emphasizes the discussion method of teaching; and fosters a warm personal learning environment. The *Field Independent Teacher* directs the goals and tempo of the class; runs a very structured classroom; is not overly concerned about student and teacher interaction; and maintains a distance from the student.

Teaching Style Models and Instruments

Because this study dealt with the matching of learning and teaching styles Gregorc's model was chosen. Gregorc has incorporated both aspects of learning and teaching styles into his model and style delineator. Gregorc believes the whole is greater than the sum of the parts, in relation to learning and teaching styles.

Gregorc's theory of style is supported by Herbster (1987), who presented an overview of studies which categorized types of learning styles, teaching models and critical thinking modes. He cites Joyce and Weil, who identified four families of human orientation to learning in *Models of Teaching:* Information Processing Family (IP), the Personal Family (PF), the Social Family (SF), and the Behavioral Systems Family (BS). These are similar to Gregorc's four learning style preferences: Concrete/Sequential (CS), Concrete/Random (CR), Abstract/Random (AR) and Abstract/Sequential (AS). Both Gregorc and Joyce and Weil's underlying assumptions are that there are differences in the way people are oriented to learning. And they both focus on the process of learning, and have identified four categories with similar identifying characteristics. Gregorc directed his study at how the individual learns and Joyce and Weil were concerned with the instructional process with emphasis on learner needs. However, both acknowledge there is considerable overlap in application of their established models.

Learning styles and models of teaching both address integral components of the educational process. Thus, learning and teaching are directly related in study and application.

Herbster analyzed the common traits between Gregorc and Joyce and Weil to establish a correlation in understanding the educational process of learning styles and teaching styles based on the four specific families of human orientation to learning. The Gregorc Learning Style Delineator was chosen by the researcher to measure teaching style of the instructors for the study, based on Herbster's analyses of the relationships observed between the two models (Herbster, 1987):

Gregorc defines the CS individual as one who has a preference for the objective, has a need for structure, and who is product oriented, and stresses the cognitive or intellectual development as a priority. Similarly, Joyce and Weil defines IP as a process of accessing, processing and organizing data in an effort to understand the environment. The models included in the IP family include: Concept Attainment, Inductive Thinking, Inquiry Training, Advance Organizers, Developing Intellect, and Scientific Inquiry. The key words of the IP are scientific method, intellectual development, and generation of solutions.

The AR style is defined by Gregorc as those people are subjective, spontaneous, person-oriented, and have high regard for the affective domain of learning. Feelings is a key word. The PF is defined by Joyce and Weil as directed at selfhood or individual development. The models of teaching in the PF are Synetics, Awareness Training, and Classroom Meetings. The key words in these models are self-expression, self concept, and affective domain in relation to the individual.

The CR style (Gregorc) is characterized by individuals who are intuitive, insightful and perceptive to the feelings of others. The key words associated with the CR style are creative, innovative and risk taking. The SF (Joyce and Weil) is described as focused on cooperation and group interaction. The key words are group learning and affective domain in regard to others. The models of teaching in the SF are Group Interaction, Role Playing, Jurisprudential Inquiry, Laboratory Training, and Social Inquiry.

The AS style (Gregorc) individual is described as one who is evaluative, concerned with excellence and modal oriented. The BS family (Joyce and Weil) is directed at modifying behavior and includes the following models of teaching: Mastery Learning, Direct Instruction, Learning Self Control, Simulations and Assertive Training.

After analyzing the similarities and relationships of Joyce/Weil's four specific families and Gregorc's four categories of learning style preference comparison of the learning styles and models of teaching the similarities were noted. Thus, the researcher chose to use one instrument, the GSD, to measure both the learning styles and teaching styles of the participants in this study.

The Gregorc Style Delineator is a self reporting instrument based on a rank ordering of four words in each of 10 sets, which makes it convenient to administer. Observations and interviews have suggested that these words can be used to aid in categorizing learning preference patterns or modes. It is for use with upper junior high students through adults and the approximate administration time is 5 minutes.

Matching Learning Styles and Teaching Styles

In view of the fact that learning differs in a wide variety of ways and these differences are likely to influence how students respond to and benefit from a given instructional method or program, determining whether to match learning and teaching styles is a complicated task. Matching can be done by matching teachers and students of the same style, matching instructional method or learning activity and student style, and matching student style with the amount of structure provided by the teachers.

A number of studies support the notion that matching student learning style to teaching style balances both performance and attitude. Citing the research of Smith and Renzulli (1984) Allen (1988) noted the achievement score of a student will increase when that student is taught through the student's preferred style. This finding came as a result of matching students' preferences to teaching modalities. Canfield (1980) found that students taught in ways that matched their learning styles "achieved higher reading scores and perceived their educational experience more positively" (Claxton and Murrell, 1987). In 1980, Canfield found that mathematics students with higher course grades had learning styles that more clearly related to the instructional styles of their instructors than did the students who received lower course grades (Canfield, 1980). Witkin (1976) reported findings indicating that under matched conditions the attitudes of students and teachers toward one another were significantly more positive than under unmatched conditions.

Many researchers take a more middle of the road position on matching (Hunt, 1971; Gregcrc, 1982; Messick, 1976). Wapner (1976) saw a variety of teaching styles as necessary to force the student into critical thinking and promote flexibility along with adaptability. Cronbach and Snow (1977) made a point of stating that there were few consistent results of matching instructional strategies to learning style preferences to improve academic achievement.

There are even researchers who favored unmatching styles. R.L. Turner (1979) along with Joyce and Weil (1986), saw learning as a time of stretching. Turner thought that if a student was predominantly taught in accordance with his learning style preference the student would fall prey to a mental and emotional "rut." Joyce and Weil's argument is that unmatching better resembles the real world that may include frustration and failure. They believed this would force the student to be adaptive, creative and determined.

According to Gregorc (1979), all teaching approaches appear to cause learners some degree of stress. This stress can be indiscernible or subtly destructive or it can be destructive. The instruction may challenge the learner's complex and delicate mind-qualities and ability to adapt (Gregorc,1979).

As the debate continues educators can better learn the value of these theories. Curtis (1991) succinctly summarized: "Learning styles and teaching styles research represents useful findings as educational researchers move to more quantifiable ways of identifying learner preferences based on the employment of learning style and teaching style inventories and other evaluative instruments" (p. 97).

Limitations and Criticisms of Learning Style Theory

While some researchers believe "style" is the most important concept to demand attention in education in many years, it hasn't been unequivocally established by researchers. Overwhelmingly, however, critics of learning style theory have singled out the self-scoring nature of learning style inventories as being the major weakness. A second concern is the stigma of one learning style being valued as "better" than another that makes some researchers hesitant to explore the potential of learning styles.

Three main critics of learning style theory are Hyman and Rosoff (1984); Grasha (1984); and Davidman (1981). Hyman and Rosoff (1984), critiqued the definitions of Dunn, Hunt and Gregorc. They took issue over the 18 elements of Dunn, Dunn and Price's (1978) model. They were not satisfied with how and why the "18" were chosen. Second, the definition did not account for native intelligence at all. Third, Hyman pointed out the lack of attention on Dunn's part to the student's behavior during the learning process. Gregorc's definition was described generally as being too vague and specifically as being limited to cognition and avoiding the affective and physiological variables of learning. Grasha (1984) questioned the reliability and validity of learning style inventories. Concerned with the self-scoring, he favored impartial observation such as essays. Leonard Davidman is the third major critic. Davidman (1981) criticized the Dunn, Dunn and Price (1978) view that learning style was unchanging. He also disagreed with the Dunn et al assumption that a person, especially an elementary student, could accurately assess his or her own learning style. He argued rather, that learning traits are changeable and that teachers should assess students through observation.

Learning Styles and Academic Performance

Although criticism exists regarding the nature of the relationship between learning styles and performance, the relationship continues to be explored. To study the relationship among problem solving behaviors and learning styles, Armstrong and McDaniel (1986) employed a computerized problem solving task. Eleven college students made choices to find their way home in a "lost in the woods" simulation. Time to read relevant information and time to make decisions were measured and correlated with learning style variables. Negative correlations resulted which indicated that subjects who took more time reading and making decisions made fewer wrong choices in finding their way home. The negative correlations were interpreted to mean that subjects with more reflective learning styles do better on this type of problem solving task. As for the relationship between learning style variables and performance on the task, students who obtained high score for deep processing made fewer wrong choices.

Ginter, Brown, Scalise and Ripley (1989) investigated whether students' learning styles affected performance in remedial college courses. Students' learning styles were categorized into five groups: Print, visual, Interactive, Split and No Preference. Type of learning style significantly influenced grade point average in remedial courses. Students using an interactive learning style had a higher mean grade point average in developmental studies than those using a combination or split of learning styles. James and Galbraith (1985) define interactive learners as:

> Individuals who learn best through verbalization.... These people like to talk and discuss ideas with other people. Small group discussions of the give-and-take of debate activities are several means through which the interactive individuals learn best (p.20).

Using the Myers-Briggs Type Indicator, Martray (1971) found that the introversion-extroversion dimension was associated with variation in ability to retain complex verbal material. O'Brien (1991), using the Gregorc Style Delineator, identified findings which suggested that the abstract sequential (AS) dimension was correlated to academic success in college.

Thompson and O'Brien (1991) later studied matched and unmatched teaching and learning styles. Using the Gregorc Style Delineator, they found no significant differences in performance for either student learning style or matched and unmatched conditions. However, analysis of data suggested that students whose learning styles were unmatched with the styles of their teachers tended to receive higher grades.

Learning Styles, Age and Gender

A related line of inquiry is the potential relationship between student gender and learning style. One potential relationship between gender and learning style was identified by Witkin's (1976) observation that males tended to be more field independent than females. O'Brien (1991) found that males tended to score significantly higher on the abstract sequential and concrete random scales than females, while females tended to score significantly higher on the abstract random scale.

Mandinach & Linn (198) tested achievement of programmers and found that a higher proportion of females were high achievers. Although males were 64% of the sample, 62% of talented students were female. Overall, females were more successful than males.

Gender differences in response to Gregorc's measure parallel gender differences in response patterns to the Myers- Briggs Type Inventory. Davenport (1986) found that males scored significantly higher on the Abstract Sequential channel while females scored higher on the Abstract Random channel. Both genders were predominantly Concrete Sequential. Similarly, Myers and McCauley (1985) report that males are most often classified as Thinking types (parallel to Gregorc's Abstract Sequential) while most females are typed as Feeling (Abstract Random) , and there are many more Sensates (corresponding to Concrete Sequential) in the general population than there are Intuitives (Concrete Random).

Learning styles and age interaction was also reported. Merritt (1983) identified significant differences between two groups of nursing students and suggested consideration be given to the development of alternative teaching and learning methods for experienced, older learners. While styles were considered consistent patterns of behavior and relatively stable traits over time, learning styles could be modified with age and experience. Davidson (1989) stated that with maturation, learning styles tend to move to greater abstraction. People also tend to become more analytical and reflective as they age.

Ginter et al (1989) conducted a study of remedial courses which investigated whether different learning styles were related to age, sex, and class-standing in a university setting. While learning style did not differ with respect to class standing or sex, learning style did differ significantly with respect to age. Individuals who indicated a print or a split preference tended to be older than those selecting a visual preference.

Using Witkin's Embedded Figures Test, O'Brien and Wilkinson (1991) found that among graduates of an associate degree nursing program, field independent persons 36 years of age and older scored significantly higher on the national nursing licensing examination than their field dependent counterparts, and higher than students in all other age groups.

Summary of Learning Styles

The research seems to indicate that learning styles are being considered in the educational process. Perhaps the most important contribution to the theory would be the development of better learning style instruments. The self-scoring nature of many inventories lends itself to reliability and validity weaknesses. Grasha's (1990) conclusion seems to accurately state the future emphasis and viewpoint for this genre of cognitive science/ education; he says: Just as there are different learning styles, I suspect that there are also different preferences for how to measure them. The issue is not what approach is better... and both quantitative and qualitative assessment procedures provide information about students that teachers sensitive to students' needs cannot afford to ignore (Grasha, p. 112).

Computer Programming

Donald Knuth (1974) provides his vision of programming, by saying:

> Computer programming is an art, because it applies accumulated knowledge of the world, because it requires skill and ingenuity, and especially because it produces objects of beauty. A programmer who subconsciously views himself (or herself) as an artist will enjoy what he (or she) does and will do it better (Knuth, p.16).

Knuth's artistic impression of programming is intriguing. And although this view was expressed as late as the 70's, even in the 1950s, scientists and psychologists strived to present programming in more organized terms. The need to examine this discipline in scientific terms has led to critical, empirical investigations in higher education and the computer industry. Investigators have moved away from Knuth's artistic description of programming. Cognitive scientists and educators must continue to investigate the cognitive effects and factors of these necessary tasks and the cognitive skills that are required to use the process called "programming."

Introduction to Programming

Programming is a term that is used loosely to describe many activities which may involve computers. Accurately defining programming is problematic because it consists of several combinations of complex activities. However, programming ability can be divided into four distinct levels: program user, code generator, program generator and software developer.

Program User. At this level one can typically execute packaged programs, such as word processors, and games.

Code Generator. The code generator knows the syntax and semantics of common commands of a programming language. He or she can comprehend other's programs and debug. Although they can write programs very little preplanning or documentation is done.

Program Generator. The program generator has mastered the basic commands. At this level, the student can read, comprehend , debug fairly lengthy programs. This level programmer also does little preplanning or documentation and does not develop user friendly software.

Software Developer. The software developer is capable of writing programs that are intended for use by others. Sophisticated programs with error traps and built-in tests ensure reliable, provable and maintainable programs. Design of the program before generating the code and full documentation are features that make programs at this level easy for others to maintain (Pea & Kurland, 1983).

The researcher studied programming at the level of software developer, since this is the goal level of the course in the study. Pea and Kurland (1983) describe this as the level at which the student writes complex programs that are intended to be used by others.

In this section, the researcher sought to identify the cognitive skills, subtasks and the cognitive differences that are present among programmers, specifically with respect to the influence learning styles may have on aspects of computer use, problem solving and computer programming.

Skills Required for Programming

Programming is made up of component skills (Shneiderman, 1980; Pea & Kurland, 1983) and each skill may favor a different cognitive ability or cognitive style. Mayer (1976) makes the argument that successful learning depends on the availability of prerequisite cognitive skills and knowledge. Five cognitive prerequisites that have been identified (Mayer) are:

1. *Mathematical Ability.* Computer programming ability has generally been suggested to be linked to general mathematical ability. Although much of computing today involves very little mathematics, children who had high scores in math were also higher achievers with LOGO (Pea & Kurland, 1983). However, Pea and Kurland also reported that there was no evidence that related general math ability and computer programming skills once general ability was factored out.

2. *Memory Capacity.* Memory is frequently observed in computer programming. It is considered a memory intensive enterprise requiring great concentration and ability to juggle values of a number of parameters at one

time. Thus, individual differences in processing capacity are likely to influence the ability to become a "good" programmer.

3. *Analogical reasoning skills.* These skills can be defined as the ability to utilize a well understood problem to provide insight and structure for the development of a solution to a less understood problem (Ginter, 1982). This fundamental reasoning process provides logical continuity in our thinking, thus it helps us solve current problems by logically referencing similar past problems that were encountered.

4. *Conditional reasoning skills.* This type of reasoning is a major component in computer programming. It determines if one is able to handle conditional statements. Conditional commands involve the operations of loops, tests, input checking and other programming functions.

5. *Procedural thinking skills.* Research suggests that these skills are affected by one's learning styles. Presumably, individuals who have a greater familiarity with the linear procedures that are analogous to the "flow of control" for commands in a computer program will more readily come to grips with the "procedural thinking," touted as a central component of computer programming expertise (Papert, 1980; Sheil, 1980).

Cognitive Correlates of Programmer Performance

Individuals typically identify a task and develop a means of assessing their skills and ability to perform it. In programming, factors that affect individual programmer performance include: cognitive style, knowledge base, intellectual aptitudes, motivational structures, personality characteristics and behavioral characteristics (Curtis, 1981;See Figure 2).

Although all of the factors are included, this study focuses on the cognitive style of the student.

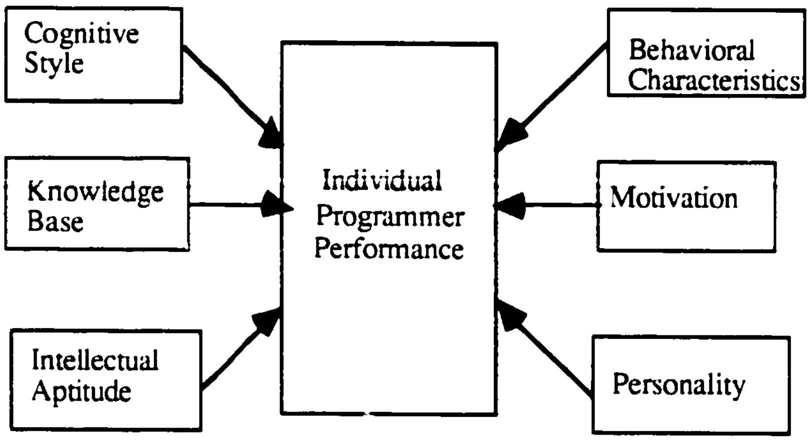


Figure 2. Factors that affect Individual Programmer Performance (Curtis, 1981, p.27).

Expert/Novice Differences.

The most documented difference between expert and novice programmers is the cognitive structure in which programming knowledge is comprehended and stored (McKeithan, Reitman, Rueter & Hirtle, 1981). Understanding the problem means the solver must set up some form of problem representation.

Studies have observed experts storing and recalling information in "chunks" whereas novices concentrate on individual items. Chunking is an extremely important concept in programming. It expands the capability of our short term mental workspace. Several items are bound together. Through experience and training, programmers are able to build increasingly larger chunks based on frequent patterns which emerge in solving problems (Miller, 1956). Much of a programmer's maturation involves observing more patterns and building larger chunks. The nature of the concepts that a programmer has been able to build into a chunk provides an indication of his/her ability. McKeithan, Reitman, Reueter, and Hirtle (1981) demonstrated qualitative differences between expert and novice programmers. In their first experiment, McKeithan et al, found that expert programmers could recall a greater portion of a memorized modular program than could novices. In a second experiment they demonstrated that some expert-novice differences could be accounted for by the schemas that programmers learn to use in organizing the knowledge they gain with experience.

The expert generally has a detailed knowledge of the problem domain, experience in the application area and creative insight. In psychological terms, expert programmers have a set of programming plans and schemas of various types as well as the ability to perform symbolic execution of these plans and debugging in long term memory that allows them to adapt or transfer their skills and knowledge to solve the specific problem at hand. After achieving an initial idea of the problem representation, the expert maps out a plan or design for the program to be written later in programming code.

Cognitive Structure.

Expert and novice programmers have different types of knowledge. This contributes to the differences in programming techniques among programmers. The experienced programmer has a complex multi-leveled body of knowledge, stored in long-term memory, about programming concepts and techniques. Part of that knowledge, semantic knowledge, includes low-level concepts, such as what an assignment statement does; what data types are; a strategy for finding the larger of two values; recursion by stack manipulation; sorting or merging methods.

At an even higher level, semantic knowledge is required to develop general approaches to problems in such areas as statistical analysis of numerical data or transaction handling for an airline reservation system. All of this semantic knowledge is abstracted through experience and instruction in dealing with programming problems, but is stored as general meaningful sets of information that are more or less independent of the syntactic knowledge of particular programming languages, utilities and subroutine packages.

> Semantic knowledge is acquired largely through intellectually demanding, meaningful learning including problem solving and expository instruction which encourages the learner to assimilate new concepts within existing semantic knowledge of ideational structure (Ausubel, 1968).

Syntactic knowledge is a second kind of information stored in long term memory; it is more precise, detailed and arbitrary (and more easily forgotten) than semantic knowledge, which is generalizable over many different syntactic representations. Syntactic knowledge, which is somewhat arbitrary and instructional, is acquired by rote, and is not well integrated within existing systems of semantic knowledge.

The acquisition of new syntactic information may interfere with previously learned syntactic knowledge since it may involve adding rather than integrating new information. Syntactic knowledge includes the format of iteration, conditional or assignment statements, valid character sets or the names of library functions. This is reflected in the observation that it is generally difficult to learn the first programming language like Fortran, BASIC, Pascal, etc., but relatively easy to learn a second one of these languages. Learning a first language requires development of both semantic concepts and specific syntactic knowledge, while learning a second language involves learning only a new syntax, assuming the same semantic structures are retained. Learning a second language with radically different semantics such as LISP may be as hard as or harder than learning a first language.

Soloway and Ehrlich (1984) argued that programming knowledge is organized into two basic components, rules of programming discourse and programming plans. Rules of programming discourse describe stylistic guides to the development of programs that are independent of particular languages or applications, such as variable names should reflect their function.

An important implication of the Shneiderman and Mayer model is that the development of programming skill requires the integration of computer science with application specific knowledge domains, such as telecommunications, radar or electronic funds transfer. Since some of these domains require years of training and experience to master, programming skill is often specific to the application domain. Newell and Simon (1972) and Anderson (1976) used a production system approach to model the rules a programmer would use in writing code for a program. A production system approach proposes that the cognitions that drive problem solving are best represented by a set of condition-action pairs called productions. These productions, according to Anderson (1982) are organized into integrated units, or production systems. The schemas and forms of these production rules vary based on the programmers' differences, and hence the significance of studying individual differences among software developers.

Cognitive Subtasks

In order to realize cognitive psychology's implications for software development, it is important to understand the cognitive processes underlying programming tasks. Dalbey & Linn (1986) characterized the development of high-level thinking skills as a chain of cognitive accomplishments along which the programmer must travel before any cognitively demanding skills are acquired.

Examination of the learning process has led to the identification of several skills required for execution of the cognitive tasks in programming.

Rarely do programmers move from the initial phase, design, to the final implementation of a program in a smooth sequence. More than likely, they repeatedly go back to various parts of the process for corrections and modification. These cognitive tasks may be related, but can be examined separately by dividing them into subtasks. They are as follows:

Problem Definition.

Design and Organization. The Design and Organization phase has the least structure and the poorest measures of success, but the greatest challenges. One-third of the entire time a programmer spends on a software project (including coding and testing) should be spent planning the task (Brooks, 1982).

According to Weinberg (1974), a tremendous amount of variability exists at this point due to varying interpretations of requirements. Molholtra, Thomas & Miller (1980) identified three stages in designing a solution for any problem and suggested that these stages are also found in the design and organization of programming. The stages are: goal elaboration, design generation and design evaluation. During goal elaboration subjects explicitly identify the goals and subgoals of the design. In design generation the requirements of the design, derived from the goals, are met by an interaction between the organization and elements of the design. The third stage, design evaluation, operates concurrently with the design generation phase and examines how well the design meets the various goals (Molholtra, Thomas & Miller, 1980, pp.125-127).

Adelson & Soloway (1984) proposed a model of program design. They use a verbal report-like methodology, in which subjects are asked to speak aloud, as a means of uncovering the cognitive processes a programmer employs during a programming subtask. The model focuses on three main properties and three components:

First, designing a program can be characterized by goals and operators. Second, the goals and operators are based on the general task of design rather than the specific task associated with the problem statement, and third, the operators interact with a knowledge base.

The three components of the model are as follows:

First is the Sketchy Model, which is a working representation of the program to be designed. This is revised and appended throughout the design process. The second component is the knowledge base, usually obtained from experience. This contains the information needed to solve the particular programming problem. Finally, the third and most developed component is the goals and operators.

Coding. Coding follows the design phase. It involves taking a problem or design for a solution and representing it in programming language syntax which can be interpreted by a compiler/translator. This process requires the ability to engage in hypothetical classes of apparent prerequisites: the ability to learn the coding templates that define the syntactical knowledge necessary for code generation, and the ability to keep to the goal or program plan at hand, unless deviation is required to generate the code (Pea & Kurland, 1984).

Comprehension. Software comprehension involves reconstructing the logic, structure, and goals that were used to write a computer program. Comprehension may take place at many levels. Thorough comprehension involves an entire spectrum. It is possible to follow each line of code without understanding the overall program function. Conversely, it is possible to understand the program function and not understand each of the steps. A middle level of understanding concerns control structures, module design, and data structures. It may be that the skills used to comprehend or recall specific chunks are not be the same skills used to understand the overall function of a program (Koubek,Salvendy, Hubert & LeBold, 1989).

Comprehension patterns may also exist. The comprehension process may also differ for short and long programs, novices and experts, low-level and high level languages or documented or undocumented programs.

Testing. Another task involved in programming that was not mentioned in most of the literature is testing. Testing is verification that the program meets the design specifications (Koubek et al, 1989).

Debugging. Debugging means removing errors from a program. There are different types of bugs. Errors may be syntactic or semantic. Syntactic errors consist of incorrect syntax in the use of the programming language being utilized. Semantic bugs are errors in the design or composition of a program. These errors may be syntactic or semantic. Gould (1975) and Gould & Drongowski (1974) developed a model which observed debugging behavior. Interestingly, the model begins with a subject's "tactic." Tactics are previously learned debugging methods which are used to search for a clue to the bug. The result is that every tactic either leads to a clue or to a dead end. A hypothesis is formulated if a clue is found, then a new tactic is based on this hypothesis. This procedure continues recursively until the bug is found. When a clue is not found the result is not necessarily useless. The lack of a clue may lead to a new hypothesis.

Documentation. Documentation is also a crucial task in programming. However, the literature concerning good documentation requirements is in much disagreement. Internal documentation, external writeups, system flowcharts, detailed flowcharts, pseudo-code and audio documentation are some of the approaches that are used. Programming languages and their usage should facilitate "self-documentation"(Weinberg, 1972). Writing meaningful and appropriate documentation is a difficult skill which must be practiced.

Modification. Modification is the final subtask to be discussed. It involves the combined skills of comprehension, composition and debugging. Shneiderman (1980) indicates that some estimates suggest up to 75% of all programming work involves modifying old software-either to correct an error or to add new functions to a program. Because of the complexity and significance of these tasks research concerning cognitive processes needs to be further developed as there is currently a vacuum in this area.

Teaching Computer Programming

Equipping oneself to effectively teach computer programming and develop effective teaching strategies is an arduous task. The approaches recommended for implementing appropriate methods of teaching programming are highly theoretical and difficult to implement.

A proponent of individualized instruction, Pask (1976) has developed some fruitful ideas in the field of learning and teaching strategies. A guiding principle in his work is the idea that educational methods are most efficient when tailored to the individual competence of the student. Basic to the strategies of teaching are the individual learning styles, or as Pask calls them dimensions of 'competence.' These styles reflect modes of organizing the acquisition, storage and retrieval of knowledge. However, it appears that the most important determinant of individual differences in programming is the relevant knowledge possessed by a programmer. Simply stated, the performance of someone tackling a complicated programming task is related to the richness of his or her knowledge about the problem area.

Specifying the level of programming expertise is also essential because different levels of programming entail different cognitive demands. According to Dillard (1985) students should learn general problem solving techniques and apply them to developing programs in a practical manner when learning a first programming language. Dillard summarized Shneider's (1978) ten essential objectives for an initial programming course.

1. Students should first be taught what constitutes a well-defined problem statement.
2. The single, most important concept in a programming course is the concept of an algorithm.
3. Introduce the duality of data structures and algorithms in the programming process.
4. Base the choice of programming language on how well it enhances the learning process.
5. The presentation of the programming language should concentrate on semantic and program characteristics rather than syntax.
6. Teachers should focus on concerns for programming style from the beginning of the course.
7. Debugging techniques should be formally presented.
8. Program testing and verification should be included in an introductory computer programming course.
9. Documentation should be presented as a phase of programming, which proceeds concurrent with programming development and testing.
10. Assignments in the programming course should not be just nontrivial assignments, but should also represent application areas.

Learning Styles and Performance in Computer Programming

The availability of computers and software has sparked the interest of several researchers. Typically, learning style studies are correlational: the goal is to describe the members of a particular occupational group or college major. Studies have been conducted with on-line searchers and data processing professionals (Bush and Schkade, 1985; Lyons, 1985). These studies characterize users according to their learning styles and hypothesize that individual characteristics as measured by a learning style inventory correlate with success. This theory has had mixed results. The majority of studies examining the relationship between learning style and performance have not had mixed results, but usually favored a particular style or styles based on the type of problem solving involved in the research.

Bernstein (1989) studied the learning styles of 21 computer users. The focus of this study was on use of microcomputer software packages. Using the

Kolb Learning Style Inventory, the author found no significant difference between learning styles, as affecting performance. However, he did find that the procedural learners did better (though not always significantly better) than the conceptual learners in every outcome measure when tested on their understanding and usage of a spreadsheet package.

Although Davidson, Savenye and Orr (1990), expected differences between abstract and concrete, the significant effect was between Sequential and Random. Utilizing Gregorc's Style Delineator they found that learners with high Abstract Sequential ability showed higher performance for computer application skills and structured programming as reflected by course grades, than did Abstract Random learners.

Summary of Learning Styles and Programming

In summary, cognitive science has provided a representation of knowledge organization and development which explains the basis for individual differences and how they may affect programmer performance.

The necessity to highlight different types of programming and the psychology involved may be useful in providing insight into how some cognitive styles may be better suited to certain types of programming.

Pointing out the cognitive activities underlying programming is a step toward improving the information about the way we actually think and process information. It also provides implications for improving teaching and learning in these areas.

Certainly, one of the demands placed on an individual in learning to program is the instructional approach. Just how significant the approach is remains to be seen. The paucity in research on learning styles and teaching styles has led to this investigation as it relates to performance in computer programming. Therefore, the following hypotheses formed the basis for this research:

1) There is an effect of matched vs. unmatched teaching and learning styles on student grades in (a) lab and (b) lecture, where learning style is measured by the Gregorc Style Delineator.

2) There is a relationship between learning style as measured by the Gregorc Style Delineator and performance in computer programming as measured by (a) lab grades and (b) lecture grades on required assignments.

3) Gender does affect student grades and there is an interaction between gender and learning style when performance is measured by (a) lab grades and (b) lecture grades on required course assignments.

CHAPTER THREE

METHODOLOGY

The study was designed to determine whether there was a relationship among learning style preferences, and teaching styles as delineated by the Gregorc Style Delineator, and their effect on course grades, and how gender may figure in this picture. The design of the study, selection and description of subjects, data collection and methods for statistical analysis are included in this chapter.

Design

The researcher used both qualitative and quantitative research methods to answer the research questions defined in Chapter One. For the purpose of this study, three independent variables were investigated for possible effect on student performance as measured by course grades: (1) learning style preferences of students, (2) matched vs. unmatched learning styles with teaching style of instructors, and (3) gender of students.

Quantitative Analysis

Quantitative data were collected in the form of (a) demographic data and (b) two dependent variables, namely, students grades in lab and in lecture.

Qualitative Analysis and Descriptive Statistics

Triangulation is meaningful when attempting to obtain the most accurate implications in a quasi experimental study. The qualitative analysis and descriptive statistics were derived from: teacher's perceptions from structured interviews; semi-structured interviews with students; field notes taken by the researcher throughout the semester; an information questionnaire; and performance as measured by course performance measures.

Subjects

To clarify the findings lab and lecture results are presented separately. The subjects (n=103) utilized in this investigation consisted of male and female undergraduate and graduate students enrolled in all sections of Computer Science 200 (lecture) and (n=92) subjects for Computer Science 203 (lab) at a large midwestern state university during the Spring semester of 1992. The 90 subjects were a subset of the 103 lecture students. Thirty-two subjects were eliminated from the study since they failed to complete the Style Delineator. Those students whose style preferences were split along the same continua, either sequential or random, were included. Males constituted 78.6% (n= 84) of the participants and females made up 21.4% (n= 22) of the lecture participants. In the lab males were 84.7% (n= 78) and females were 15.3% (n= 14). The modal age category of all subjects was under twenty-five (25) and the modal classification was freshman. Over two-thirds (81.5%, n= 86) were under twenty-five.

The total enrollment for the classes was 135. Of those 103 subjects completed the inventory, and the demographic data sheet, and fell into an actual learning style category. Of those 103 subjects 92 were enrolled in the lab.

Teachers in the study consisted of one professor who taught the lecture section and two Graduate Teaching Assistants, who each taught one lab section.

Demographic Data

To provide descriptive and qualitative statistics data were obtained concurrently from a questionnaire inquiring about gender, age (coded dichotomously), major, grade point average, prior experience of computer programming and previous enrollment (Appendix C).

Subjects were asked to list the courses in programming that they had previously taken. The number of structured programming courses were taken into account. Unstructured programming courses such as BASIC and packaged software were not included. Nine students had enrolled previously and dropped or failed the course. Eleven (10.7%) of the students had previously enrolled in the course. Teachers who were also included in the study were one instructor for the lecture and two teaching assistants one for each lab section. The lecture students were divided into 3 sections which were taught by the same professor.

All students enrolled in the course were asked to participate in taking learning style inventories.

Instrumentation

Both learning styles and teaching styles were determined by giving students, the professor and the two teaching assistants the Gregorc Style Delineator (GSD) (Gregorc, 1982a). The Gregorc Style delineator is a self assessment instrument for identifying and quantifying learning styles of adults. The instrument consists of ten sets of four words with individual rank orders. Based on the total of the rankings, four basic learning style abilities/teaching style abilities are revealed: Abstract Random (AR), Abstract Sequential (AS), Concrete Random (CR), and Concrete Sequential (CS). According to Gregorc, the learning/teaching style theory represents an evolution of mediation ability theory which states that "the human mind channels through which it receives and expresses information most efficiently and effectively" (Gregorc, 1982b, p.5). It is purported to measure the mediation (cognitive) abilities of perception and ordering. Gregorc suggests that while all individuals possess some base level of ability in all four dimensions, most individuals exhibit a natural predisposition toward one or two of the styles and that these predispositions "affect not only how we view the world and ourselves, but also how we are perceived by that world" (Gregorc, 1982, p.6). In *An Adult's Guide to Style*, Gregorc (1982), the distinguishing traits and behaviors of persons dominant in each of the four learning styles are outlined.

The reliability of the Gregorc Style Delineator is assessed in terms of internal consistency using standardized alphas as the statistics, and in terms of stability using test-retest correlation coefficients as the statistics. The validity of the Gregorc Style Delineator was assessed in terms of construct validity by interview, predictive validity by correlation between style delineator scores and attribute scores, and responses to the descriptions resulting from the Style Delineator. Gregorc (1982c) reported reliability coefficients ranging from .89 for the AS scale to .93 for the CR scale and predictive validity correlations ranging from .55 to .76. O'Brien (1990) found reliability coefficients of .64 for the CS scale, .51 for the AS scale, .61 for the AR scale and .63 for the CR scale. In the same study, confirmatory factor analysis indicated that while all of the separate items did not serve well as measures of their respective scales, jointly they meet minimal standards for factor definition and provide adequate measurement scales for the four styles. While the reliability is somewhat low, the instrument may be profitable for research purposes.

Data Collection Process

The research investigator used the following procedure for collecting the data. The Gregorc Style Delineator was administered in the last few days of the course. In order to provide consistency, the directions as printed in the test manuals were read. The tests were administered on the same day for the entire sample. The time was purposely chosen for introduction to learning styles so as not to influence student's learning preferences and teaching preferences and contaminate the results of the study.

The course was conducted by one instructor for the lecture and two graduate assistants for each lab sections. However, since teaching styles of the three instructors could have been different, the teaching styles were also taken into consideration. The two lab sections of the course used the same syllabus, course content outlines, time schedule and evaluation criteria for the projects and quizzes. Students' results of the learning style inventory were made available to them upon request. Instructors learned their respective styles after the completion of the study and were given information to make them further aware of learning styles and teaching styles theory and models. All information was kept confidential. Confidentiality was maintained throughout the study by randomly assigning a code to each individual student during data collection and analysis. Participation in the study was voluntary as outlined by the university right of subjects policy (see Appendix B). In order for the study to not affect students' grades, data were coded and analyzed after the course ended and final grades had been submitted to the registrar.

Course Format and Student Groupings

In the lecture course, the instructor's teaching/learning style was determined to be Abstract Sequential. Students whose GSD scores put them in that category were considered to be in the Matched group. All other students were in the Unmatched group (see Table 1). The dependent variable here was the grade in the lecture course, a grade which was determined by eight quizzes testing concepts. (Note: Instrumentation is described more fully on p. 47)

For lab section I, the teaching assistant's teaching/learning style was determined to be Abstract Sequential. Again, students whose GSD scores put them in that category were considered to be in the Matched group.

All other students were in the Unmatched groups (see Table 2). The dependent variable here was the grade in the lab course, a grade which was determined by a series of programming assignments and quizzes testing concepts (see Appendix I for an example of quiz questions and programming assignments).

Table 1

Distribution Of Matched And Unmatched Students For Lecture

Matched	Unmatched
AS n= 13	AR n= 19
	CR n= 37
	CS n= 31
	AS/CS n= 3
Total n = 103	

Table 2

Distribution Of Matched And Unmatched Students For Lab I (Teaching Style = AS)

Matched	Unmatched
AS =6	AR = 4
	CR = 19
	CS = 24
	AS/CS = 2
TOTAL = 54	

For lab section 2, according to the GSD, the teaching style of the teaching assistant was a split combination of abstract sequential and concrete sequential preferences. Therefore, the data were collapsed. The learners whose GSD scores placed them into either the abstract sequential or concrete sequential categories were considered as matches. All others were placed in the unmatched category (see Table 3). The dependent variables here, as in lab section 1, were programming assignments and quizzes.

Table 3

Distribution Of Matched And Unmatched Students In Lab 2
(Teaching Style = Split AS/CS)

Matched		Unmatched	
AS	= 6	AR =	11
CS	= 11	CR =	9
AS/CS	= 1		
TOTAL	= 38		

Course Materials

Both CS 200 (lecture) and 203 (lab) required both declarative and procedural knowledge on the use and understanding of computer programming skills in Pascal. The basic topics of the course are shown (See Appendix E).

The course format was a combination of lecture, discussion, required readings and programming assignments.

Course Projects

Course projects were assigned in the lab. They consisted of programming assignments incorporating the topics that were covered in the lecture and lab periods of the class. The dependent variable performance, was studied from a compilation of the grades of quizzes, and programming assignments, into one numeric grade, with 100 points maximum.

Quizzes

In addition to programming assignments, quizzes were given periodically to test concepts covered in the course.

Observations

Observations were also made by the researcher, who conducted semi-structured interviews with students in the course, and who took field notes by attending the lab and lecture courses in the beginning of the semester, the midterm, and the latter part of the semester.

Interviews

Interviews are useful in verifying perceptions and reports elicits elicited from the survey population (Lincoln and Guba, 1985). They may generate a rich source of information about student attitudes toward teaching and learning, the way they learn and the preferences they have for instructional techniques. Fifteen students were interviewed to determine additional attitudes, feelings and conceptions or misconceptions of the students and teachers about the learning process of programming and the instructional design of the course. The interview style selected was semi-structured. This style was chosen over the unstructured interview. The interview questions were formulated to gather general and specific information about learning, teaching, classroom dynamics, content, learning styles, principles of adult education and improvement of instruction (See Appendices F, G).

Statistical Analysis

Statistics reported in the study were obtained from printouts of the Statistical Package for the Social Sciences (SPSS-X release 3.0 for IBM OS/MVS) processed at the Kansas State University computing center.

The following steps were used to analyze the data:

1. To determine effects of matched and unmatched conditions, t-tests addressed hypothesis 1. The independent variables incorporated were learning style, teaching styles and course grade in the form of averages in the lecture and lab.

2. T-tests addressed the relationship between learning style and course grade (avg) in the lecture and lab.

3. A t-test was conducted to determine the mean differences between males and females.

4. Two-Way Anovas were performed to examine the interaction of gender and learning styles on course performance measures.

Summary

The researcher's goal was to determine the relationship between learning style, teaching styles and performance in an introductory Pascal computer programming course. This chapter presented information concerning the specific research questions and hypotheses, both quantitative and qualitative, that the researcher set forth to address in this study. A detailed discussion of data analysis and statistical operations is presented in Chapters Four and Five.

CHAPTER FOUR

FINDINGS

This study investigated the effects of (1) matched and unmatched student learning styles and instructor teaching styles, (2) student learning styles, and (3) gender on course grades in lecture and lab in a computer programming course. The goal of this chapter is to present analyses of data relevant to each hypothesis.

Organization of Results

In addition to taking a learning style delineator, each participant filled out a demographic questionnaire. The results of descriptive statistical procedures such as frequencies and measures of central tendency are presented in order to convey an overall impression of the characteristics of the sample. Analyses are then detailed with reference to each of the hypotheses shown in Chapter 3.

Distribution of Subjects

The distribution of subjects by student classification is as follows: 51 freshmen (49.5%), 23 sophomores (22.3%), 16 juniors (15.5%), 11 seniors (10.7%), 2 graduate students (1.9%).

The distribution of subjects by major is presented in Table 4. This information was further used to identify the background of the subjects, but was not used as part of the research design or statistical analysis.

Table 5 provides additional data concerning the distribution of grade point average (GPA) as a total selected sample, and within and between subsets of each learning style preference.

The distribution of grade point average was divided into three classifications : low- below 2.00; average -2.00 to 2.99 and high - 3.00 to 4.00. Of the total 90 reported GPAs, 36 subjects had average grade points and 48 had high grade point averages.

Table 4

Distribution Of Subjects By College Major

Major	n Lecture	n Lab
Computer Science /Info. Systems	19	19
Engineering	32	27
Education	13	13
Other	39	33
Total	103	92

Table 5

Distribution Of Reported Grade Point Averages

Learning Styles (Lecture)					
	CS	AS	CR	AR	AS/CS
LOW	2	0	0	0	1
AVG	13	3	13	2	0
HIGH	16	7	15	7	1
NOT REPORTED	6	3	3	9	1
TOTALS	37	13	31	19	3

Learning Styles (Labs)					
	CS	AS	CR	AR	AS/CS
LOW	2	1	0	1	0
AVG	14	3	11	6	1
HIGH	15	6	13	8	2
NOT REPORTED	5	2	2	0	0
TOTALS	36	12	26	15	3

The subjects' learning styles as ascertained by the GSD are shown in Table 6. In the lecture course there were 37 Concrete Sequential subjects, 27 males and 10 females. All 13 Abstract Sequential subjects were male. There were 31 Concrete Random subjects, 27 male and 4 females. Eleven males and 8 females were identified as Abstract Random and 3 males that were identified as split (AS/CS) preferences.

In lab 1, there were 11 Concrete Sequential subjects, 10 males and 1 female. All 7 Abstract Sequential subjects and all 9 Concrete Random subjects were male. Of the 11 Abstract Random learners 6 were male and 5 were females. There was also one split (AS/CS) preference male.

In lab two there were 25 Concrete Sequential students, 19 males and 6 females. All 6 Abstract Sequential subjects were males and all 17 Concrete Random learners were males. Women made up 2 of the 4 Abstract Random learners. There were 2 split (AS/CS) preference males.

The Gregorc Style Delineator was used to identify teaching/learning style. The professor of the lecture course was identified as Abstract Sequential (AS). The Graduate Teaching Assistant of Lab section 1 was identified as Abstract Sequential and the Second lab Graduate Teaching Assistant was identified as a split (AS/CS) preference.

Table 6

Learning Style of Students by Gender

	Lecture		Lab 1		Lab 2	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
CS	27	10	10	1	19	6
AS	13	0	7	0	6	0
CR	27	4	9	0	17	0
AR	11	8	6	5	2	2
AS/CS	3	0	1	0	2	0

Data gathered from the instruments (learning style inventory, quizzes and programming assignments) were analyzed to examine both main effects and interactions when the variables learning style, teaching style and performance were investigated. The following questions were structured to provide direction to the study:

1. Will students who are matched to the learning/teaching style of the instructor and teaching assistants perform better than those who are unmatched when performance is measured by (a) lecture course grade (b) lab course grade?

2. Is there a significant relationship between learning style and performance in computer programming as measured by the GSD and course grades in (a) lecture and (b) lab?

3a. With respect to course grades is there a main effect of gender on either lab or lecture grades?

3b. Is there an interaction of gender and learning style on either lab or lecture grades?

Examination of the Hypotheses

This section addresses the three hypotheses which were designed to determine the effects of learning styles, teaching styles and gender on performance in computer programming.

Hypothesis #1: Matched vs. Unmatched learning/teaching styles

Table 8 shows a comparison of mean grade scores in lecture and lab for matched and unmatched subjects. The grading scales for the courses were as follows: (a) lecture112 and above = A, 98-111 = B, 87-97= C, 76-86 = D and 75 and below = F. For the (b) lab, 90 and above = A, 80-89 = B, 70-79 = C, 60-69 = D and below 60 = F.

Table 7

Matched vs. Unmatched Mean Scores (lecture)

	n	M	SD
Matched (AS)	13	97.42	12.60
Unmatched (AR, CS, CR, AS/CS)	90	99.94	14.83

Table 8

Matched vs. Unmatched Mean Scores (labs)

	Lab 1		
	n	M	SD
Matched AS	6	78.92	9.98
Unmatched CR, AR, AS/CS	48	77.74	16.78

	Lab 2		
	n	M	SD
Matched AS/CS, AS, CS	18	86.26	13.29
Unmatched AR, CR	20	82.50	20.30

There was no significant difference between the Matched vs. Unmatched groups' performance as measured by lecture or lab grades. T-tests were computed on the final grade scores obtained from lecture and from each lab. For lecture, the mean score for the Matched group was 97.42 and the mean for the Unmatched group was 99.32, $t\ (13,90) = 1.42$, $p < .51$. Because one lab instructor clearly fell into the Gregorc AS category and the other was split (AS/CS), t-tests were calculated separately for the two lab groups. Neither was found to be significant, but Matched students out performed Unmatched students in both labs.

For lab I, the Matched mean grade was 79.82 and the Unmatched mean was 77.74 $t(6,48)= .17$, $p<.868$. Lab 2 was the one whose instructor was split (AS/CS) . Because of the split style, subjects with AS, CS and split AS/CS were grouped together as the Matched group. For lab 2 the Matched mean grade was 86.26 and the Unmatched mean was 82.50 $t(18,20) = 0.67$, $p<.509$. T-tests for the combined labs yielded the following results: $t(24,68) =1.33$, $p< .186$

<u>Hypothesis # 2: Learning Style</u>

There was a significant difference among learning styles as measured by lab grades, but not the lecture. The mean grade for each learning style category is presented in Table 9. Since Concrete Sequential learners scored higher consistently, t-tests were run comparing Concrete Sequentials versus all other learning styles in lecture and lab. In the lecture the t-test was not significant, $t(36, 67) = 1.42$, $p<.164$. For the combined labs, the Concrete Sequential learners were compared to all the other learning styles yielding the following significant results: $t(36,56) = 2.45$, $p<.006$.

To further examine learning styles in the lab, the data were collapsed into sequential vs. random learners. That is, all Sequential (Abstract Sequential, Concrete Sequential), learners were grouped together as were all Randoms (Abstract Random, Concrete Random). Table 10 shows the results. There were significant differences between Sequential and Random student scores, with Sequential students outperforming Random students for the combined lab sections $t\ (48,41) = 2.24$ at $p <.044$. The Random learners (Abstract Random and Concrete Random) had a lab course mean score of 80.39 and the

Sequentials (Abstract Sequential and Concrete Sequential) had a lab course mean of 83.28. Concrete vs. Abstract learners' scores were not significantly different. The results were t (62, 27) = 1.49, $p < .662$.

Table 9
Comparison of Learning Styles and Course Grade Means

Learning Style	n	M	SD
		Lecture	
CS	37	102.58	15.34
AS	13	97.42	12.59
CR	31	96.74	15.16
AR	19	97.20	12.62
AS/CS	3	101.50	6.58
		Lab 1	
CS	25	82.47	13.24
AS	6	78.92	9.98
CR	17	73.12	20.16
AR	4	78.25	13.33
AS/CS	2	57.00	14.14
		Lab 2	
CS	11	89.72	6.83
AS	6	78.38	19.74
CR	9	85.74	12.08
AR	11	74.04	25.49
AS/CS	1	95.50	n/a

Table 10

Comparison Of Mean Scores of Sequential vs. Random, both labs*

Learning Style	M	n
Sequential (AS,CS)	83.28	48
Random (AR, CR)	80.39	41

(*Split AS/CS learners were omitted in this analysis)

Table 11

Comparison Of Mean Scores of Concrete vs. Abstract, both labs*

Learning Style	M	n
Concrete (CS,CR)	81.67	62
Abstract (AR, AS)	85.94	27

(*Split AS/CS learners were omitted in this analysis)

Hypothesis # 3a: Gender

There was not a significant effect of gender on performance in either the lecture or lab courses. However, females performed better than males in both courses, as shown in Table 12. Probability values for the t-tests are also shown in Table 12.

Hypothesis # 3b: Gender and Learning Style

Gender and learning style means are shown in table 13. To determine the interaction of gender and learning style on performance a Two way ANOVA was run. Notice in table 13, there are several empty cells because two learning styles had no females. Results of the analysis of variance statistical procedure did not reveal a significant difference for either gender, learning style or interaction of learning style by gender for course grade in the combined lab (See Tables 14 and 15).

There were no significant differences found between the mean course lecture scores of male and female Concrete Sequential learners t(27,10) = 2.47, $p < .150$ nor was there significance in the lab t(29,7) = 1.37, p <..41.

Abstract Sequential and Concrete Random learners could not be analyzed in the same manner because all of the subjects in these learning style categories were male. Abstract Random males vs. females showed no significant difference t(11,8) = 1.62, $p < .45$) in the lecture course nor was there was a significant difference shown in the lab t(8,7) = 1.26, $p < .069$.

Because of the empty female cells, the learning style categories were collapsed along the Sequential/Random and Concrete/Abstract continua. The interaction of gender and learning style on performance was not significantly different. The collapsed means are shown in Table 15.

Table 12

Comparison of Course Mean Performance of Males and Females

	n	M	SD	p
Lecture				
Males	75	98.409	14.24	p<.445
Females	28	100.821	15.31	
Lab 1				
Males	46	76.75	16.68	p< .224
Females	6	82.50	10.80	
Lab 2				
Males	32	83.76	18.17	p<.675
Females	8	87.65	11.70	
Combined Labs				
Males	78	79.63	17.54	p<.214
Females	14	85.47	10.83	

Table 13

Male vs. Female Course Means by Learning Styles

	Lecture			
	CS	AS	CR	AR
Male	101.35	96.78	96.74	94.12
Female	111.05	n/a	n/a	105.82

	Lab			
	CS	AS	CR	AR
Male	84.94	78.65	77.49	72.47
Female	83.59	n/a	n/a	87.35

Table 14

Two-way Analysis of Variance comparison by gender and learning style on lab course performance in labs (collapsed)

Concrete/Abstract

Lab Average	df	MS	F	p
Gender	1	447.299	1.633	.205
Learning Style	1	223.219	.815	.369
Gender X Learning Style	1	229.555	.838	.362

Table 15

Two-way Analysis of Variance comparison by gender and learning style on lab course performance in labs (collapsed)

Sequential vs. Random

Lab Average	df	MS	F	p
Gender	1	381.043	1.731	.237
Learning Style	1	579.319	1.419	.146
Gender X Learning Style	1	328.914	1.225	.272

Table 16

Male vs. Female Course Means (Collapsed Labs)

	Concrete	Abstract
Male	81.42 (n=56)	76.18 (n=20)
Female	83.59 (n=6)	87.35 (n=7)

	Sequential	Random
Male	85.54 (n=42)	78.96 (n=34)
Female	82.56 (n=6)	87.35 (n=7)

Narrative Summary of Findings for the Three Major Hypotheses

1. There was no significant difference between Matched and Unmatched groups performance on course performance as measured by lecture course

grades nor was there a significant difference for lab grades. (Matched students outperformed Unmatched students).

None of the female subjects matched the teaching style of the instructors in lecture or lab. However, these unmatched females outperformed the matched males. Overall averages of females was higher than males in both lecture and lab.

2. There was no significant difference among the five learning styles on either performance measure. However, when all Sequential students were compared with all Random students, there was a difference in favor of Sequential learners (in the lab grade only).

The researcher conducted a post hoc comparison to determine whether the Concrete Sequential learning styles showed a significantly higher performance in the course compared to the other learning styles, as the means might suggest. T-tests for the entire lab sample were conducted. The t-tests compared CS to the other learners combined (AS, AR, CR, AS/CS) as well as to the other categories separated. In the former, $t(36,56) = 1.94$, $p<.05$. The t-tests conducted between CS and each individual learning style did not yield significant results.

3a. Females had higher mean scores for both lab and lecture. The greatest difference in lab averages was between Abstract males and females. was with Concrete Sequential learning style, as measured by lab grade.

3b. The interaction of gender and learning style was not found to be significant. However, the sequential learners had higher course means.

Male Concrete Sequential (CS) students had the highest averages of the other male learners in both lecture and lab. Female Abstract Random (AR) learners had the highest averages of the females in the lab course. On the contrary, male AR learners had the lowest averages in the lecture and lab compared to the other male learners.

To determine whether the groups were different to begin with, grade point average was determined for the four learning styles. Abstract Random (AR) learners in the labs had the highest GPAs of the learning style categories (2.97). However, more Concrete Sequential (CS) students (16) fell into the high GPA category.

Ancillary Questions

Some of the areas included (a) the effectiveness of the teaching staff (b) the effect of the two parts of the course being separated, (c) the feelings about the course content , and (d) how the students felt the course could be improved. This section reports on the perspectives of students in the course to those four aspects of the course. The results are reported in the observations and interviews section.

Student Interview Observations

At the end of the semester, fifteen volunteers representing a wide range of grades were selected to take part in personal interviews to determine the effectiveness of the course, materials, and instructors. The Student Interview Outline (Appendix G) was used as a guide for the student interviews.

In the lecture sections, the lack of attendance by the majority of the students was noticeable. Although there was a large number of students in the course, few bothered attending the lecture.

For ex.

Q: Why don't you attend the lecture regularly?

Responses:

1- "I don't feel like I really learn anything there."

2- " I just read the book and my notes."

3- " I don't really see the point".

The second point of interest was the professor's teaching style. The course was conducted in a straightforward lecture, using the blackboard as the medium for delivery. During the lecture there was very little exchange of information, although the professor did often ask if there were any questions.

When observing the lab sections, the researcher noticed that they appeared to be less formal than the lectures. There was also more interactivity between the teaching assistants and the students. Most of the students attended the labs.

In addition to hands on time to work on programs, the teaching assistants also lectured on the topics that were being covered in the lecture. Students asked questions often and then tried to apply those answers to the programs they were working on.

The instructional design of the two courses seemed somewhat complex. The lab students were often ahead or behind the lecture topic although they had to study those lecture topics for quizzes. It appeared that there wasn't frequent conversation between the professor and the teaching assistants. Some of the students also found the separation of two classes confusing. It appeared that there was disjunction between the classes yet they were required to be taken together.

Q: Responses about the two courses being taken together

Responses: 1-"We're never at the same place in the notes."

2- "The bulk of the work is done in the lab but the lecture is 3 credits and the lab is only 1."

3- I don't know why we don't get one grade.

Instructor Interview Observations

The teacher interviews elicited responses about the administrative and instructional value of the classes as well. The professor of the lecture section did not really feel as though his learning/teaching style was important to the success of the student. But he did try to find out about students styles by giving an essay assignment at the beginning of the semester.

The lab instructors had no prior knowledge of learning style theory but felt that their instruction was very helpful to the students because they were able to work with them in a hands-on environment. In that environment they could help solve problems and assist in programming techniques. Administrative problems that were mentioned by the students were echoed by the teaching assistants. That is, they too felt that the classes were disjointed and they were never really at the same point in the lecture and the lab.

CHAPTER FIVE
DISCUSSION

The purpose of this study was to investigate any significant relationships that exist among learning style preferences and teaching style preferences as measured by the Gregorc Style Delineator and course grades. In addition, the study looked at gender in this context. An examination of the issues relating to these findings will include the research questions, the theories, previous research, limitations that affected the findings, and future research recommendations.

Research Questions

1. Will matching versus unmatching of student and instructor learning styles affect performance in computer programming?

The lack of significant findings for the unmatched learning styles/teaching styles may agree with the lecture professor's viewpoint, that the responsibility is up to the students to match with the teacher's style or way of thinking to really understand the theories involved in programming. It's also possible that unmatched learners self-selected themselves out of the course.

2. Will learning style affect performance?

Overall, there was no significant difference among learning styles in the computer programming course, but a significant difference was found between Sequential and Random students in the lab.

The one constant seems to be that Concrete Sequential categorized learners tend to achieve higher grades than those in other learning style categories. Surprisingly, however, the Abstract Random learners had higher GPAs than the other learners in the labs. The fact that more CS learners had higher mean GPAs is not surprising based on the results reported by

Davidman(1981) and O'Brien (1991), who found that CS learning style is associated with higher achievement in college. However, the fact that Abstract Random learners would have the higher GPAs is not consistent with any literature reviewed for the study.

3. Does gender interact with learning style?

The results in this study seem to confirm the equity problem that exists in many technical, and science programs at universities. First, the extremely small number of women in the course, is a major issue today. However, the female's small group seem to have been an above average group of women based on the course scores and GPAs. In fact women outperformed men in all learning style categories in which there were women. However, this difference was significant only in the lab groups. Overall, women significantly outperformed men in both lecture and lab, when learning styles were compared.

This research presumes that the groups were no different to begin with, and in fact the overall demographic differences of the groups were very minor. Seemingly the students had a similar background as far as prior programming experience. The majors were very diverse, but predominantly technical majors were enrolled in the course.

Conclusion and Implications

The first hypothesis examining Matched and Unmatched conditions, was measured by the course quizzes (lecture) and assignments (lab). There was no significance found here. This suggests that although the learning styles are certainly not causal of grades, there is the indication that there is a relationship among learning styles and they certainly need to be further explored.

The fact that there were so few women in the sample (22) may account for some of the significance due to unequal n s in the analysis. In light of the research and review of literature, the following recommendations are offered.

The first relates to the theory that those subjects with greater degree of Concrete Sequential characteristics will tend to do better in computer programming courses that require skills necessary for procedural programming without regard for the teaching style. This study supports that theory. Although according to predictive studies (Davidson, 1990), CS students tend to be higher achievers in studies on college and in programming, it would be expected that they would have higher grades. However, with the instructors' strong Abstract Sequential characteristics, the ability to adapt to the highly abstract quality of instruction may have a bearing on how well students are able to utilize their knowledge base and transfer skills when presented with materials in very abstract terms.

Because the hypotheses of this study were confirmed to a degree by the data, there are some implications which could have an important effect upon the approach colleges and universities take toward counseling students about taking courses or majoring in computer science and in helping students who are having difficulty with such courses. These implications could also serve as the basis for further research on the subject of learning styles as a indicator of potential success in the pursuit of a career in a computer related field. The findings on learning styles further show the need to examine the cognitive process with respect to analytical skills.

There is a need to look more deeply at the younger students and keep track of them for longer periods of time to help us better understand performance and cognitive aspects of learning, and to help us aid students attaining necessary skills to be successful.

Looking at the prerequisites, we see that students with a strong background in high school mathematics and related subjects will perform better in college subjects which require programming. However, by the time a student reaches college he or she may have acquired and probably maintained a learning style and mathematical ability level for quite some time. They have also acquired learning strategies that may or may not be working toward their benefit.

The study could also serve as an indicator of teaching styles as it affects student learning. By familiarizing teachers with learning/teaching styles theory perhaps we can help them better respond to a diversity of styles and provide some basis for the instructional design of the course.

The learning style instrument should also be a focal point for improvement in this area. The reliability and validity of present instruments remain lower than one would desire.

Recommendations

Though learning style does have some implications, and some basis for examination, further in-depth research requires the development of stronger instruments. However, having some idea of the students' learning style does serve as a guide to improving and/or adapting teaching style.

Teacher education programs must stress the need to be aware of the types of learners in the classroom. How often do college students say, "I'll take that class when so and so teaches it next fall." It may not be that there is less work to do or that the work is harder, but by the time students reach college, a lot of them are intuitively aware of their learning style and that's how they know a certain teacher isn't right for them. This problem is magnified when equity and multicultural issues and learning styles factor into the equation.

The findings of this study suggest that there is a vast amount of research remaining on learning styles theory. There are so many counterparts to learning styles that need to be examined, that aren't addressed by the Gregorc Style Delineator. The situation is even more complex when one is dealing with a technical course where the concept of mental models is paramount and the use of computing equipment is prevalent..

The fact that the women in the course had higher mean scores than the men was not expected since the literature has shown the inequity of women in science. However, the increased performance may mean that the women who were enrolled were brighter than the men, on average. The higher course grades could also account for the dedication and hard work that may have been brought on by the anxiety of not being expected to do well.

Matching learning styles appeared to be of little importance in both lab and lecture sections. By observing the students throughout the semester the author concluded that one reason matching was less of an issue with these students was because they formed study groups and made team efforts to work with each other on problems. Cooperative learning became a factor, many students matched themselves with a classmate and/or tutor. This is a viable and practical solution for any learner. Teachers should look more seriously at cooperative learning. Webb, Ender & Lewis (1986) found that not only may group work increase students' opportunities for experience, but also suggest that there is no evidence that group work with computers is less effective than individual work for learning.

Recommendations for Further Study

Based on the questions raised by this study, the following recommendations for further research investigation are proposed:

1. Replicate the present study in different large and urban schools to compare findings. Increase in the number of subjects would strengthen the validity and generalizabilty of the data. Information drawn from a wider, larger sampling would make using more rigorous statistical procedures possible to determine correlations, interrelationships to support decisions concerning the

inclusion of specific components in a teacher preparation program for teachers of all subject matters.

2. Broaden the study to investigate the teaching style differences among elementary, secondary and higher education instructors.

3. Investigate the learning style differences among elementary, secondary and higher education and students.

4. Investigate in more detail the relationship between age and teaching/learning style.

5. Investigate in more detail the relationship between teaching style and the teacher's subject area.

6. See that practitioners in education assess their own learning and teaching styles.

7. Explore the issues of how and whether an individual's preferred learning style is modified by the educational environment.

Final Thoughts

The learning style of an individual may be used as an indicator of how well that person might do in a field of endeavor related to computer programming. However, the question that seems to become more pertinent is do we use the predictive quality of learning styles as a screening out method or as an evaluative tool in early stages to help strengthen some of the weaker characteristics of certain "types" of learners. Either decision has associated weaknesses. Those in the educational arena have to decide whether the goal is to provide equal opportunity education, or to say certain students should not be here anyway because they don't have "what it takes".

It is my sincerest hope that learning styles theory can be optimized in the learning process. That is, learning style theory needs to be used to facilitate the inclusion of various learning styles rather than as an instrument of exclusion.

<u>Bibliography</u>

Allen, R. (1988). The Relationship Between Learning Style and Teaching Style of Secondary Teachers in South Central Kansas. Unpublished doctoral dissertation, Kansas State University, Manhattan, KS.

Ausubel, D.P. (1968). Educational Psychology: A cognitive view. New York: Holt, Rinehart & Winston.

Barbe, W.B., & Milone, M.N. (1981). What we know about modality strengths. Educational Leadership. Feb, 378-380.

Bokoros, M. A.(Aug. 1990) Common cognitive personality factors in non-clinical measures. A paper presented at the Annual Convention of the American Psychological Association

Brooks, R. Studying programmer behavior experimentally: The problems of proper methodology. Communications of the ACM, 1980, 23 (4), 207-213.

Canfield, A. (1980). Learning Styles Inventory Manual. Ann Arbor, MI: Humanics Media.

Claxton, C.S., & Murrell, P.H. (1987). Learning styles: Implications for improving educational practices. ASHE - ERIC Education Report, College Station, TX.

Cronbach, L.J., & Snow, R.E. (1977). Aptitudes and Instructional Methods: A Handbook for Research on Interaction. New York: Irvington Publishers.

Cummings, C. (1990). Teaching makes a difference. Edmonds, WA: Snohomish Publishing Co.

Curtis, C. (1991). An Assessment of the extent of perceived knowledge and usage of learning styles and Principles of Adult Education at Alabama State University. Unpublished doctoral Dissertation, Kansas State University, Manhattan, KS.

Davenport, J. (1986). Learning style and its relationship to gender and age among elderhostel participants. Educational Gerontology,12, 205-217.

Davidman, L. (1981). Learning style: the myth, the panacea, the wisdom. Phi Delta Kappan, 62, 641-645.

Davidson, G.V; Savenye, W.C.; Orr, K. (Nov. 1991). How do learning styles relate to performance in a computer applications course? A paper presented at Association for the Development of Computer- Based Instructional Systems.

Dunn, R., Dunn, K., & Price, G.E. (1978). Learning style inventory and productivity environmental preference survey. Lawrence, KS: Price Systems, Inc.

Doyle, W., & Rutherford, B. (1984). Classroom research on matching learning and teaching styles. Theory into Practice, 23, 10-19.

Fischer, B. B. & Fischer, L. (1979). Styles in teaching and learning. Educational Leadership, 36, 245-251.

Friedman, P. & Alley, R. (1984). Learning styles: applying the principles. Theory into Practice, 23, 77-81.

Gade, D. (1982). Comparison of Learning Style Preferences and Creative Behavior of Male and Female Education Students at The University Level. Unpublished Doctoral Dissertation, Kansas State University, Manhattan, KS.

Garcia, R.L. (1982). Teaching in a pluralistic society: Concepts, models, strategies. New York: Harper & Row.

Ginter, E.J.; Scalise, J.; Brown, S.; Ripley, W. (1989). Perceptual learning styles: their link to academic performance, sex, age and academic standing. Perceptual and Motor Skills, 68, 3 pt.2, 1091-1094.

Goldstein, K. & Blackman, S. (1978). Cognitive Style. New York: John Wiley and Sons.

Grasha, A.F. (1984). Learning Styles: The journey from the Greenwich observatory to the college classroom. Improving College and University Teaching, Winter, 46-52.

Grasha, T. (1990). The naturalistic approach to learning styles. College Teaching, 33, (3), Summer, 106-113.

Gregorc, A. F. (1982). An Adult's Guide to Style. Maynard, MA: Gabriel Systems, Inc.

Gregorc, A. F. (1982a). Gregorc Style Delineator. Maynard, MA: Gabriel Systems, Inc.

Gregorc, A. F. (1982c). Gregorc Style Delineator. Maynard, MA: Gabriel Systems, Inc.

Guild, P. B., & Garger, S. (1985). Marching to different drummers. Alexandria, VA: Association for Supervision and Curriculum Development.

Hill, J. E. & Nunnery, D. N. (1973). The Educational Sciences. Bloomfield Hills, MI: Oakland Community College Press.

Hunt, D. E. (1971). Matching Models in Education. Ontario: Ontario Institute for Studies in Education.

Hunt, D. E. (1982). The practical value of learning style ideas. In Student Learning Styles and Brain Behavior: Programs, Instrumentation, Research (pp. 6-12). Reston, Va.: National Association of Secondary Principals.

Hyman, R. & Rosoff, B. (1984). Matching learning and teaching styles: the jug and what's in it. Theory into Practice, 23, 35-43.

Joniak, A. J. & Isaksen, S. G. (1988). The Gregorc Style Delineator: Internal consistency and its relationship to Kirton's adaptive - innovative distinction. Educational and Psychological Measurement, 48, 1043-1049.

Joyce, B., & Weil, M. (1986). Models of Teaching. Englewood Cliffs, NJ: Prentice Hall.

Keagan, J., Moss, H. A. & Sigel, I. E. (1963). Psychological significance of styles of conceptualize. Monographs of the Society for Research in Child Development, 28, (2 Serial No. 86).

Keefe, J. (1982). Student learning styles and brain behavior. Reston, VA: National Association of Secondary School Principals.

Knowles, M. (1973). The Adult Learner: A Neglected Species. Houston, TX: Gulf Publishing Co.

Knuth, D. (1974). The Art of Computer Programming, Reading, MA: Addison Wesley Pub. Co.

Kolb, D. (1984). Experiential learning: Experience as the source of learning and development. New York: Prentice - Hall.

Kolb, D. (1985). Learning style inventory. Boston: McBer and Company.

Lawrence, G. (1984). A synthesis of learning style research involving the MBTI. Journal of Psychological Type, 8, 2-15.

Littauer, F. (1983). Personality Plus. Old Tappan, NJ: Fleming H. Revell Company, 1-190.

Mandinach, E.B. & Linn, M. (1987). The cognitive consequences of programming: achievements of experienced and talented programmers. Journal of Educational Computing Research, 3 (1), 53-71.

Mayer, R.E. (1976a). Comprehension as affected by the structure of the problem representation. Memory & Cognition, 4 (3), 249-255.

Mckeithen, K.B., Reitman, J.S., Rueter, H.H., & Hirtle, S.C.(1981). Knowledge of organizational and skill differences in computer programmers. Cognitive Psychology, 13.

Messick, S. (1976). Individuality in Learning. San Francisco: Jossey - Bass.

Miller, G.A. (1956). The magic number seven, plus or minus two. Psychological Review, 63, 81-97.

Myers, I. B., & Briggs, K. C. (1983). Myers-Briggs type indicator. Palo Alto, CA: Consulting Psychologist Press, Inc.

Myers, I. B., & McCaulley, M.H. (1985). Manual: A guide to the development and use of the Myers-Briggs type indicator. Palo Alto: Consulting Psychologists Press.

Newell, A & Simon, H.A. (1972). Human Problem Solving. Englewood Cliffs, NJ: Prentice-Hall.

O'Brien, T.P. (1990). Construct validation of the Gregorc Style Delineator: An application of LISREL 7. Educational and Psychological Measurement, 50, 631-636.

O'Brien, T.P. (1991). Relationships among selected characteristics of college students and cognitive style preferences. College Student Journal, 25, 492-500.

Pask, G. (1976). Styles and strategies of learning. British Journal of Educational Psychology, 46,128-148.

Pea, R. D. and Kurland, D. M. (1983). On the cognitive prerequisites of learning computer programming. Bank Street Center for Children and Technology, Tech. Report #8, 1983.

Ramirez, M., & Castaneda, A. (1976). Culture Democracy, Bicognitive Development and Education. New York: Academic Press. (1989)

Reichmann, S., & Grasha, A. (1974). A rational approach to developing and assessing the construct validity of student learning styles scales instrument. Journal of Psychology, 87, 213-223.

Schmeck, R. (1977). Development of a self-report inventory for assessing individual differences in learning processes. Applied Psychological Measurement, 1(3), 413-31.

Shneiderman, B. Software Psychology: Human Factors in Computer and Information Systems. Cambridge, MA: Winthrop, 1980.

Shneiderman, B. (1982). Control flow and data structure documentation : two experiments. Communications of the ACM, 25 (1), 55-63.

Smith, L., & Renzulli, J. (1984). Learning style preferences: A practical approach for classroom teachers. Theory into Practice, 23, 45-49.

Soloway, E., Bonar, J., & Ehrlich, K. (1984). Empirical studies of programming knowledge. IEEE transactions on Software Engineering, 10 (5), 595-609.

Thompson, M.J. (1989, Fall). Validation of the Gregorc learning style model. Occupational Education Forum, 18 (1), 27-37.

Thompson, M. J. & O'Brien, T.P. (1991). Learning Styles and Achievement in Postsecondary Classrooms. A paper presented at the Annual Conference of the American Educational Research Association.

Turner, R. L. (1979). The Value of Variety in Teaching Styles. Educational Leadership, 35, 257-258.

Van Merrienboer, J.J.G. & Paas, F.G.W.C. (1990). Automation and schema acquisition in learning elementary computer programming: implications for the design of practice. Computers in Human Behavior, 6, 3, 273-289.

Weinberg, G. (1971). The Psychology of Computer Programming. NY: Nostrand Reinhold Co.

Witkin, H. (1976). Cognitive style in academic performance and in teacher-student relations. Individuality in Learning, In Messick and Associates (Eds.), San Francisco: Jossey-Boss.

Witkin, H., Moore, C. A., Goodenough, D. R. & Cox, P. W. (1977). Field-Dependent and Field - Independent cognitive styles and their educational implications. Review of Educational Research, 47, 1- 64.

Appendix A

PERMISSION TO USE COPYRIGHT MATERIALS

Permission to use the "Gregorc Style Delineator" was granted by Anthony F. Gregorc, Ph.D.; Gregorc Associates: PO Box 351; Columbia, Connecticut 06237-9405.

GREGORC STYLE DELINEATOR ™
RESEARCH INSTRUMENT

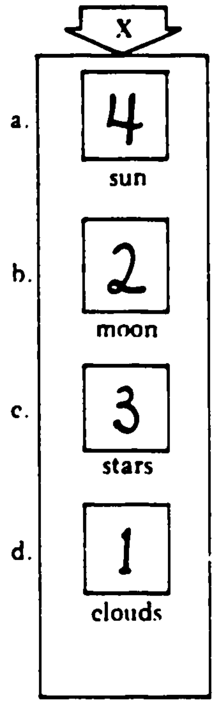
DIRECTIONS

Before starting with the word matrix on the next page, carefully read all seven of the following directions and suggestions:

1. **Reference Point.** You must assess the relative value of the words in each group using your SELF as a reference point; that is, who you are deep down. NOT who you are at home, at work, at school or who you would like to be or feel you ought to be. THE REAL YOU MUST BE THE REFERENCE POINT.

2. **Words.** The words used in the *Gregorc Style Delineator* matrix are not parallel in construction nor are they all adjectives or all nouns. This was done on purpose. Just react to the words as they are presented.*

Example



3. **Rank.** Rank in order the ten sets of four words. Put a "4" in the box above the word in each set which is the best and most powerful descriptor of your SELF. Give a "3" to the word which is the next most like you, a "2" to the next and a "1" to the word which is the least descriptive of your SELF. Each word in a set must have a ranking of 4, 3, 2 or 1. No two words in a set can have the same rank.

4 = MOST descriptive of you
1 = LEAST descriptive of you

4. **React.** To rank the words in a set, react to your *first impression*. There are no "right" or "wrong" answers. The real, deep-down you is best revealed through a first impression. Go with it. Analyzing each group will obscure the qualities of SELF sought by the Delineator.

5. **Proceed.** Continue to rank all ten vertical columns of words, one set at a time.

6. **Time.** Recommended time for word ranking: 4 minutes.

7. **Start.** Turn the page and start now.

*For an explanation on how and why these words were chosen, see the "Development" section of *An Adult's Guide to Style*

Appendix B

INFORMED CONSENT

You are invited to be a part of a dissertation research study. I hope to determine the relationship between learning styles, teaching styles and performance in computer programming. This research will help us to determine the extent to which learning styles impact on students and teachers at Kansas State University.

If you decide to take part, I will:

1. Administer 2 instruments.

a. Administer a Gregorc Style Delineator during a regularly scheduled lecture section of the course (CIS 200), which you are currently taking.

b. Administer a short questionnaire to be answered at the same time.

2. In addition, I will be sitting in on classes periodically and taking some field notes.

3. I will also be asking a few students some questions about their coursework.

4. The results of the study will not in any way effect your grade in the course CIS 200/203. No one will know your individual results, all data are presented only as group data.

5. The results of this study's findings about learning will be made available to your instructor when they become available.

6. Information about learning styles will be provided for you upon completion of the inventory, if requested.

Your name will not be associated with any reports of the research. Only the researcher will have access to the information you provide. If you have any questions, about the research, now or in the future, please feel free to ask them.

I will be glad to answer them fully and honestly. You can contact me, Daphne A. Moses at 446 Bluemont Hall or call 532-6024 or 537-4771. If you decide to take part, you are free to withdraw your consent and to discontinue participation at any time. Please understand that this study does not provide financial compensation to subjects.

I have read the above statements and have been fully advised of the procedures to be used in this project. I volunteer to participate.

____________ ______________________________

date signature of participant

Appendix C

Student Data Sheet - CS 200/203

1. ID No.________________________

Please Circle one:

2. Classification: FRESH SOPH JR SR GRAD

3. Gender: Male Female

Please Check one of the following:

4. Age: Under 25_____ 25 and over____

Please fill in the following:

5. Major____________________ Minor______________________

6. Please answer the following questions:

Have you ever enrolled in CS 200/203 during any previous semester?

YES___ NO___ If so, when_____________________

Have you had any prior computer programming courses? If so, list the language(s) studied and the year(s) taken.

Language(s) Year(s)

Appendix D

Teacher Data Sheet

Position (Title): ______________________

Please circle the number which corresponds to the answer that best describes you.

SEX

1- Male 2- Female

AGE

1- 20-25	6- 46-50
2- 26-30	7- 51-55
3- 31-35	8- 56-60
4- 36-40	9- 61-65
5- 41-45	10- 66 +

TOTAL years of professional school teaching experience

1- Not applicable

2- 0-5 years

3- 6-10 years

4- 11-15 years

5- 16-20 years

6- 21-25 years

7- 26-30 years

8- 30+ years

Appendix E

Course Topics for CIS 200

contents

notes.01:Slack, Chapter 1

Keywords:Abstraction, computer, computer system, operating system, high-level language, low-level language, machine language, editor, compiler, linker, loader, debugger,environment.

notes.02:Slack,Chapters 1, 2

Keywords:commands, programs, source text, compiler, language, legibility and understandability of programs.

notes 0.3:Slack, Chapter 2

Keywords:Algorithm. What is a 'program', and where is it? Compiler directives.

notes 0.4:Slack, Chapters 2, 3, 6

Keywords:Program flow, selection of execution paths, statement, semicolon separator.

notes 0.5:commentary

Keywords:Why comments, why compilers are unforgiving.

notes 0.6:Slack, Chapter 3

Keywords:Shape of procedures, pre-and post-conditions, comments, performance report.

notes 0.7:Slack, Chapter 3, (chap. 8), commentary

Keywords:Variable, value, name, address, scope, visibility.

notes0.8:Slack, Chapter 4 and 8.4, commentary

Keywords:VALparms and VARparms for procedures

notes 0.9:Slack, Chapter 4

Keywords:Iteration, FOR loop.

notes 10:Slack, Chapter 5

Keywords:Input and output, ASCII, Newline, synchronization, buffering, value and representation.

notes 11:Slack,Chapter 5, (ch.12)

Keywords:Types, ordinals, conversions, function, recursion.

notes 12:Slack, Chapter 5, (ch.12)

Keywords:Recursion, stack, activation record, stack overflow.

notes 13:Slack, Chapter 8, commentary

Keywords:Protection of variables, name-calling.

notes 14:Slack, Chapter 6

Keywords:IF, ELSE, CASE.

notes 15:Slack, Chapter 6

Keywords:Boolean algebra, DeMorgan, logic operators, precedence rules, IFF (shorthand for IF and ONLY IF).

notes 16:Slack, Chapter 7

Keywords:IF, CASE, procedure, function, FOR, WHILE, REPEAT, correctness, modularity, loop invariant.

notes 17: Slack, Chapter 7.3; commentary

Keywords:Problem analysis, loop examples, keyboard input.

notes 18:Slack, Chapter 7

Keywords:Sequence of tests, evaluation of logic expressions

notes 19:Slack, Chapter 7.5

Keywords:Real numbers, floating-point representation, representation error.

notes 20:Slack, Chapter 8

Keywords:Types, type declarations, subranges, enumerated types, instances of a type.

notes 21:Slack, Chapter 8.5

Keywords:Files and file access, support structure, file descriptor, file pointer, file window, TEXT datatype,

ASSIGN, RESET, REWRITE, APPEND, CLOSE.

notes 22:Slack, Chapter 8.5

Keywords:Record, EOLN, EOF, tests for file existence.

notes 23:Slack,chapter 8.6; commentary

Keywords:Nested functions and procedures, Units, information hiding.

notes 24:Slack, Chapter 9,10

Keywords:Structured data type, attribute, record, field, array.

notes 25:Slack, Chapter 9.3

Keywords:Searching on arrays, linear search, binary search, sentinel, guard, key, big-o notation, algorithm.

notes 26:Slack, Chapter 9.2

Keywords:Sorting on arrays, bubble sort, exchange sort, selection sort, insertion sort, quick sort, merge sort.

notes 27:Slack, Chapter 10.2, 10.5

Keywords:Abstract Data type (ADT): queue, stack, string.

INTERFACE section, IMPLEMENTATION section of T-P Unit.

Enqueue,serve, push, pop. Ring buffer, keyboard handler.

MOD, WITH.

notes 28:Slack, Chapter 13

Keywords:dynamic space, pointers, linear linked structures.

NEW, DISPOSE, Traverse, support structure.

notes 29:Slack, Chapter 12,13.5

Keywords:Binary search tree, root, leaf.

Recursion, shell procedure. Searching and insertion on trees.

Tree traversals: In-order, pre-order, post-order.

Appendix F

TEACHER INTERVIEW OUTLINE

INTERVIEW AREAS:

Learning styles and teaching styles

Principles of Adult Education and Improvement of Instruction

INTERVIEW METHOD:

Lincoln and Guba's unstructured interview style

Questions:

How do you feel about the large number of students in the course?

Are department standards meeting the needs of the students?

What are some hindrances or constraints to teaching a course of this nature?

How important is learning styles?

How important is teaching style?

Do you think your teaching style has changed?

What dictated that change?

How important to instruction are knowing and understanding a student's learning style?

Do you consider college students to be adult learners?

In what ways do your syllabi and course planning allow for shared decision making by your college students?

Have you ever taken a course on college teaching?

Appendix G

STUDENT INTERVIEW OUTLINE

INTERVIEW AREAS:

Are you aware of learning styles theory?

Were the courses what you expected?

How were they different?

What did you like/dislike about the instruction?

What grade do you expect in the classes?

Why did you do so well?/ Why did you do so badly?

How would you describe the style of your lecture professor?

How would you describe the style of your lab instructor?

Appendix H

Sample and solution from CIS 200 final exam

1. A queue implemented with an array to hold its data items will always have at least one array element that does not contain data waiting to be served. Please explain why.

On an empty queue the PUT index must mark an empty element, and on insertion of a data element that element will then contain the oldest unread data. Thus on an empty queue both the PUT index and the GET index will mark the same array element, and the EMPTY test can be based on equality of the two indices. Furthermore, this arrangement requires that both PUT and GET indices will be updated AFTER use. Now if the last free element in the queue were filled, the PUT and GET indices would again have the same value, but the queue would then be full, instead of empty, and the EMPTY test would return TRUE on a full queue. To eliminate the erroneous EMPTY test the queue is marked FULL when only a single used element remains.

Abstract

This study examined the relationship among learning styles, teaching styles, gender and performance in a college computer science course.

There were n=103 subjects in the lecture and n=92 from the lab course. Subjects were assigned a learning style category according to their score on the Gregorc Style Delineator. A demographic questionnaire was completed and 15 volunteers were interviewed. The instructors (n=3) from the courses were categorized according to their learning /teaching styles. The student's course grades were provided with their consent.

Analyses regarding matching versus unmatching of learning styles revealed no significant difference in the lecture, or the labs. However, Matched students outperformed Unmatched students in the labs.

Learning style and performance analyses resulted in no significant differences in course grades for the lecture or the lab. When the lab data were further collapsed, into Sequential versus Random learners, results yielded significance at <.044. Additionally, when Concrete Sequential learners were compared to all the other learners, they was a significant difference at p<.006.

Group means for gender and learning style were tested. The course averages of females were higher in both the lab and the lecture sections of the course. The females also tended to be predominately Concrete Sequential learners, which is the learning style associated with academic success. However, in the lab section of the course, it was the Abstract Random learners who had the highest course averages, though not significantly greater.
The interaction of gender, learning style and performance was not significantly different.